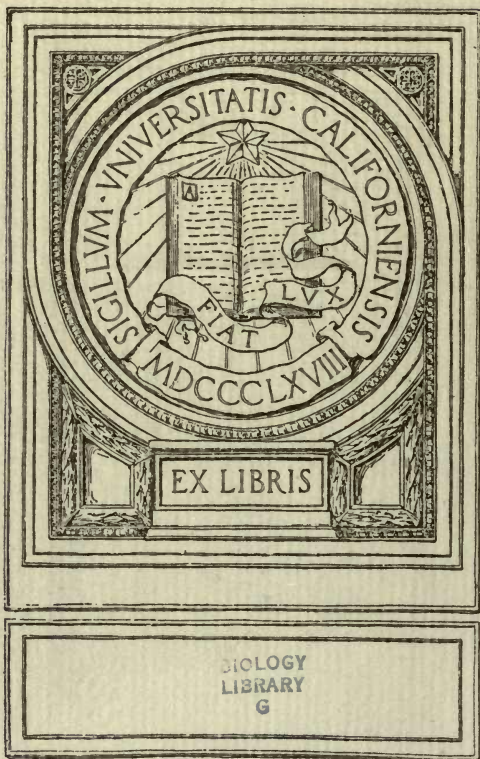


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Instruction in  
Physiology for School teachers

H. Newell Martin.

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JOHNS HOPKINS UNIVERSITY,

BALTIMORE.

INSTRUCTION IN PHYSIOLOGY FOR SCHOOL  
TEACHERS.

ANNOUNCEMENT.

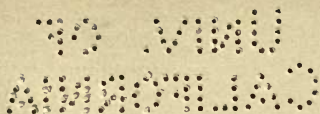
Professor MARTIN will organise, during the present session, a class for the instruction of School Teachers *in Physiology*. It will be strictly limited to school-teachers, or students of a Normal College, who are engaged in teaching, or who purpose to teach, Physiology. Only eighteen students can be received.

The class will meet in Hopkins Hall, on Saturday mornings, at 10 A. M., commencing on Saturday, October 13; and after a lecture, will adjourn to the Biological Laboratory for practical instruction, which will continue until 2 P. M.; those who may be admitted to the course must undertake to give this time uninterruptedly to the work. The class will have twenty meetings, and absence from any one of them, unless for a cause which the authorities of the University may deem satisfactory, will be treated as a resignation, and the absentee's place be filled up forthwith.

Microscopes and other instruments, and the necessary material, will be provided by the University. Students will be required to make good any injury, beyond fair wear and tear, occurring to an instrument while in their charge.

Candidates for admission to the course are requested to send in applications to the President of the University at once, and those who are accepted will be notified of the fact.

A registration fee of one dollar will be charged to each accepted student.



## OBJECT AND PLAN OF THE COURSE.

The following extract from the first lecture of the course for which the succeeding Laboratory Notes were written, will serve to explain with what object and upon what plan the "Teachers' Class" was organized.

"It has of late years come to be pretty generally recognized that no scheme of elementary education is complete which does not include instruction in the elements of some of the experimental and observational sciences, so that, side by side with training in the principles of language and of mathematics, training in these other subjects, which are calculated to exercise different powers of the mind, may find a place. Some sort of teaching in them is therefore commonly attempted in schools, and in spite of great difficulties is often excellently accomplished; and there are now, I think, few teachers of experience who do not recognize their value, or who have not (as one advantage at least) found that many children who seemed hopelessly dull and indolent in the study of other subjects have, when brought in contact with these, brightened up and excelled all others in them.

"These newer school studies, however, labor under some disadvantage as compared with the older and more time-honored ones. As is to be expected, less perfected methods of teaching them have at present been attained; the experience of years in such matters cannot compete with the experience of centuries: and there is at present even some danger that through untrained zeal in teaching them much of their value as educational agencies will be overlooked or discredited. So many things are mainly taught by books that it often needs some readjustment of ideas to grasp the conception that there are things in school routine which cannot be properly taught by books; but none the less it is patent on the least consideration, that if a child be loaded up with the facts of Physics or Chemistry or Physiology out of a book, he will indeed gain a knowledge of facts whose utility and interest is undeniable, but as far as the special educational value of the experimental sciences is concerned he may nearly as well, or perhaps better, be learning how to 'orderly decline his noun and his verb,' and how

to add together dollars and cents. The real value of these subjects lies in the fact that while, as a rule, more attractive to children, they admit, with much greater ease and certainty than most others, of the systematic training of the faculties of observation and of the powers necessary for drawing correct conclusions from a number of observed facts. A child may be taught that acids neutralise bases verbally or from a book, and may even know by heart all the equivalent portions of acids and bases necessary for neutralisation, but the educational value of Chemistry in school training will be far better utilised if he be made to try with his litmus paper a few acids and a few bases and mixtures of them, and be thus led to draw for himself the conclusion that in certain proportions acids and bases do commonly produce a neutral mixture.

"The great objection to such teaching is the difficulty of obtaining and using the appliances and material. The difficulty is a real, and in most schools at present a great one, but still much more may be done in simple and easy ways than one who has not tried is commonly disposed to believe; and even in cases where the objects or phenomena concerned cannot be shown themselves, a great step is made if those who teach about them have themselves seen them; if the teaching is not the mere giving out of an abstract of a teachers' manual, boiled down from some text-book, which in its turn is abstracted from another, so that the facts get chilled and deadened by four or five stages of removal from the actual observation of the phenomena themselves, but comes with something of a natural glow still on it.

"It is with the object of helping to make the teaching of Animal Physiology alive and potent as an educational tool that this class has been organized. I shall naturally not try to lead you into the advanced branches of the subject, but shall simply endeavor to give those of you who care for it a real and not a book acquaintance with the fundamental facts of the science, and of so much of anatomy as is necessary for comprehending it.

"Our general plan will be first to meet here for a lecture; but that will be the least important part, for I do not suppose I shall tell you anything in it that you have not heard or read of already, and often it

will be a very short one—just serving to hold matters together somewhat. After the lecture we will adjourn to the Laboratory, and there will study the subjects of the lecture on the things themselves; and my hope is that in that way you will learn how to set about showing those facts in animal structure and function which are adapted for being shown in a school; and as to other important facts not so adapted, you will, at least, have seen them for yourselves, and be better able to teach about them than any amount of reading alone will ever qualify you to be. For it may, I think, be laid down, as one more of the rules without exception, that in teaching such subjects as this, the fresher the teacher comes from the observation of the facts the better; even if he has seen a phenomenon a hundred times before, and feels he knows all about it, there is no preparation for a lesson like looking at it once again ”

## ELEMENTARY PHYSIOLOGY.

### *Laboratory Directions.*

#### I.

##### SUPPORTING ORGANS AND TISSUES.

*Paragraphs in brackets are to be omitted until the rest of the section has been worked through; and are then to be taken up, should time permit.*

1. Examine and sketch a “long” bone — say *humerus* or *femur*.

Note—*a. Shaft and extremities*: the *head* of each bone, the *neck* of the *femur*: the prominences on the extremities (*tuberosities, trochanters*).

*b. The articular surfaces*: their form, smoothness, &c.

*c. The rough lines and patches on the bone, marking the places where muscles have been attached.*

*d. The aperture (foramen) for the entrance of the medullary vessels*: two such are present in the *femur*.

2. Examine and draw the cut surface of a humerus or femur which has been longitudinally divided.

Note—*a.* The *medullary cavity*.

*b.* The *compact* and *cancellated bony tissue*: the distribution of each.

3. Examine and draw a *vertebra*.

Note—*a.* Its *body* and *arch*: the *neural canal*.

*b.* The *spinous*, *transverse* and *articular* processes.

*c.* The anterior and posterior (upper and lower) surfaces of the *body*—not so smooth as the articular ends of humerus or femur.

*d.* Place two consecutive vertebræ together, and note the *inter-vertebral foramina* and the contact of the articular processes. Draw.

*e.* Examine an articulated vertebral column.

4. Examine a calcined bone; and a bone which has had its earthy matter removed by acid. Observe that the earthy matter alone or the animal matter alone retains perfectly the form of the original bone.

5. Examine with your microscope (Eyepiece 2, Objective A,) one of the prepared thin transverse sections of bone: carefully draw a portion.

Note—*a.* The *Haversian canals*.

*b.* The *lacunæ*.

*c.* The *canaliculi*.

*d.* The general lamellated appearance of the tissue, the *lamellæ* being for the most part concentric with some Haversian canal.

6. Examine your section with Eyepiece 2, Obj. D. Note more especially the canaliculi, which will not have been well seen with the lower power. Draw a few lacunæ with their canaliculi.

7. Examine microscopically the specimen which has been prepared to show the *bone corpuscles*.



8. Open and examine a fresh joint, observing as you do so, the various tough bands and membranes (*ligaments*), which hold the bones together.

Note—*a.* The glairy *synovial fluid* moistening it.

*b.* The smooth, pale *cartilage* covering the ends of the bones.

*c.* The texture and consistency of the cartilage: it cuts easily, is flexible and elastic.

9. With your razor cut off a thin slice of the cartilage, (in a plane vertical to that of the head of the bone,) mount it in water, and examine, first, with Oc. 2, Obj. A. and then with Obj. D. Draw carefully.

Note—*a.* The general *ground substance*, or *matrix*, of the cartilage: homogeneous or slightly granular.

*b.* The *cartilage corpuscles* distributed singly or in groups.

*c.* The tendency of the groups to assume the form of rows, perpendicular to the bone near the attached surface of the cartilage; parallel to it near the free surface.

- [10. Examine the forms of the articular surfaces and the movements permitted between the bones in a *ball and socket joint* (shoulder or hip,) a *hinge-joint* (elbow), and a *pivot joint* (atlanto-axial).]

- [11. Examine other forms of articulation.

*a.* That between some of the cranial bones (*suture*).

*b.* That between the vertebral bodies: note the *intervertebral disc* directly uniting the bones, without the intervention of any synovial surfaces.]

12. Dissect out and examine one of the ligaments of a synovial joint.

Note—*a.* Its points of attachment and the mode in which it acts, either to keep the bones in contact, or to check movement in some direction.

*b.* Its color, flexibility, toughness and inextensibility.

13. Tear apart with needles a very small bit of ligament, in a drop of water. Examine with Oc. 4, Obj. D. Draw carefully.

Note in this *white fibrous connective tissue*—

- a. It is mainly composed of very fine fibres.
  - b. The fibres run parallel, often in a wavy course.
  - c. Having finished your drawing, run a little dilute acetic acid in under the cover-slip: the fibres, for the most part, swell up and disappear—for those which remain see 12 b.
  - d. Examine and sketch the specimen which the demonstrator has prepared to show the *connective tissue corpuscles*.
14. Examine, as described in last section, a bit of ligament taken from between the arches of the vertebræ. Draw carefully.

Note in this *yellow elastic tissue*—

- a. The fibres, much coarser than those of the white fibrous tissue, and often branched; observe the way the broken ends curl up.
- b. Run in acetic acid: the fibres are unaffected; those fibres which remained unaltered by the acetic acid, (12 c) in your last specimen, were fibres of this tissue, mixed in the ligament with the white fibrous tissue.
- c. Note the extensibility and elasticity of this tissue, as displayed in a piece of *ligamentum nuchæ*.

## II.

### BLOOD AND LYMPH.

1. Examine a fresh drop of your own blood with the microscope (Obj. D, Oc. 2 or 4). Run a little oil around the edge of the cover-glass, to prevent evaporation.

Note—

- a. The solid particles (*corpuscles*) floating in a fluid (*plasma*).

- b.* The corpuscles are of two kinds: the more numerous variety (*red corpuscles*) are of a pale yellow color, (unless massed together when they appear reddish) and float about freely; the other variety (*white corpuscles*) are much less abundant, and tend to stick to the glass.
- c.* As the red corpuscles float about, notice their form: seen in full face they are circular, seen edgewise they are somewhat of the shape of a finger-biscuit; careful examination will show that they are biconcave discs.
- d.* When a corpuscle is seen in full face, its centre will be bright and its edge darker, or *vice versa*. This depends on the central depression, in consequence of which the corpuscle acts somewhat as a biconcave lens, and rays of light passing through do not all emerge parallel and reach the eyepiece.
- e.* Shortly after the blood has been drawn, the majority of the red corpuscles adhere by their broad sides and form rows, the so-called *rouleaux*.
- f.* The white corpuscles slowly change their form: sketch the outlines of one at intervals of fifteen seconds. If necessary, the demonstrator will heat the specimen on a warm stage so as to promote the movements.
- g.* After a time the rouleaux break up and the corpuscles float freely again.
- h.* Finally, fine threads of *fibrin* may be seen stretching across the microscopic field.
- i.* By this time probably, many of the red corpuscles will have become puckered or *crenate*.

Draw red corpuscles as seen in various aspects while floating; also in rouleaux. Draw several white corpuscles to illustrate the various shapes they assume.

2. Treat a fresh-drawn drop of blood with a little dilute acetic acid, run in under the cover-slip. The red corpuscles swell up and become spheres instead of discs, and finally the coloured portion (*hæmo-globin*) is discharged into the surrounding fluid, and only the colorless framework (*stroma*) of the corpuscles is left ; finally, the stroma also disappears.

3. Examine blood of frog or newt. Draw.

Note as regards the red corpuscles—

*a.* Their size : they are considerably larger than the human red corpuscles.

*b.* Their form : seen in front they are oval, and about twice as long as broad ; seen edgewise they are linear, with a slight bulging about the centre. Observe the apparent form in intermediate positions.

*c.* Their structure : at first apparently homogeneous pale yellow bodies, a central portion (*nucleus*), different from the rest, soon becomes visible in them.

[*d.* Treat your specimen with magenta ; the nucleus will become deeply stained : no such body can be stained in the mammalian red corpuscle.]

4. Examine the colorless corpuscles carefully. They exhibit more active movements at the temperature of the room than the corresponding human corpuscles usually do. Sketch the outline of one at intervals of fifteen seconds.
5. Treat a drop of newt's blood with acetic acid : the red corpuscles swell up and lose their coloring matter ; their nuclei and those of the colorless corpuscles become conspicuous.
- [6. Examine specimens of various bloods, as that of rabbit, dog, bird, &c.]



7. Watch the process of coagulation of fresh-drawn blood : at first perfectly liquid, it gradually becomes viscous, then sets into a jelly adhering to the bottom and sides of the containing vessel ; next follows the pressing out of the first few drops of *serum* on the top of the gelatinised mass and the "cupping" of the latter ; finally, the contraction of the mass in every direction, while more serum passes out, until the *clot* floats quite free in a considerable quantity of liquid.
8. Note the "*buffy coat*" on the clot exhibited by the demonstrator.
9. Whip some fresh-drawn blood, collect the *fibrin*, wash and examine it : its color, extensibility and elasticity.
10. Examine blood kept from coagulating by large quantities of neutral salts. Note that it clots on dilution.
11. Prepare artificial clot by mixing pericardiac fluid and blood-serum.
12. Examine the fibrinogen and fibrino-plastin exhibited by the demonstrator, and the clot obtained by mixing solution of the former with serum and of the latter with pericardiac fluid.
- [13. Examine crystals of *Hæmo-globin*, the so-called *blood crystals*.]
- [14. Examine a drop of lymph under the microscope. Note in it the corpuscles floating in a plasma : all like the colorless blood corpuscles.]

### III.

#### ANATOMY OF THE SHEEP'S HEART.

*In the following directions "dorsal" means the side of the heart naturally turned towards the vertebral column ; "ventral" the side next the breast bone ; "right" and "left" refer to the proper right and*

*left of the heart when in its natural position in the body; "upper" means more towards the head in the natural position of the parts; and "lower" the part turned away from the head.*

1. Take the sheep's *heart* and *lungs* provided for you; lay them on their dorsal sides with the windpipe turned away from you, and arrange them in their natural relative positions. Note the loose bag (*pericardium*) in which the heart lies, and the bit of midriff (*diaphragm*) which has been left attached to it.
2. Carefully dissecting away adherent fat, &c., trace the vessels named below until they enter the pericardium. Be very careful not to cut the veins, which, being thin, collapse when empty, and may be easily overlooked until injured: as each vein is dissected out, stuff it with cotton wool. When all the vessels have been prepared, draw them.

- a. The *vena cava inferior*: find it on the under (abdominal) side of the diaphragm; thence follow it through the tendinous part of that organ until it enters the pericardium, about three inches further up: to follow it in this part of its course, turn the right lung towards your left and the heart towards your right.

The vein just below the diaphragm will be seen to receive several large vessels, the *hepatic veins*.

As it passes through the midriff, two veins from that organ enter it.

Between diaphragm and pericardium it receives no branch, but lying on its left side will be seen the lower end of the *right phrenic nerve*, ending below in several branches to the diaphragm.

- b. *Superior vena cava*: seek its lower end, entering the pericardium about one inch above the entry of the inferior cava; trace it up to the point where it has been cut across, stuff and clean it.
- c. Between the ends of the two *venæ cavæ* will be seen the two *right pulmonary veins*, proceeding from the lung and entering the pericardium; clean and stuff them.

3. Turn the right lung and heart back into their natural positions ; clean away the loose fat in front of the pericardium, and seek and clean the following vessels in the mass of tissue lying above the heart, and on the ventral side of the windpipe.

*a.* The *aorta* : immediately on leaving the pericardium, this vessel gives off a large branch ; it then arches back and runs down behind the heart and lungs, giving off numerous branches on its way.

*b.* The *pulmonary artery* : this will be found imbedded in fat on the dorsal side of the aorta. After a course, outside the pericardium, of about an inch, it ends by dividing into two large branches (right and left pulmonary arteries,) which subdivide into smaller vessels as they enter the lungs. Notice the obliterated vessel (*ligamentum arteriosum*) passing from the undivided pulmonary trunk to the under side of the aortic arch.

*c.* Observe the thickness and firmness of the arterial walls as compared with those of the veins ; they stand out without being stuffed.

4. Notice on the ventral side of the left pulmonary artery, the *left pulmonary veins* passing from the lung into the pericardium.
5. Clean away fat, &c., from the windpipe (*trachea*), and make out the entrances of its subdivisions (*bronchi*) into the lungs.
6. Slit open the pericardiac bag, and note its smooth, moist, glistening inner surface, and the similar character of the outer surface of the heart. Cut away the pericardium carefully from the entrances of the various vessels which you have already traced to it. As this is done, you will notice that inside the pericardium the pulmonary artery lies on the ventral side of the aorta.

7. Note the general form of the heart—that of a cone with its apex turned towards the diaphragm. Very carefully dissect out the entry of the pulmonary veins into the heart. It will probably seem as if the right pulmonary veins and the inferior cava opened into the same portion of the organ, but it will be seen subsequently that such is not really the case. Note on the exterior of the organ the following points :
  - a.* Its upper flabby *auricular portion* into which the veins open, and its denser lower *ventricular* part.
  - b.* Running around the top of the ventricles is a band of fat, an offshoot of which runs obliquely down the front of the heart, passing to the proper right of its apex, and indicating externally the position of the internal partition which separates the right ventricle, which does not reach the apex of the heart, from the left, which does.
  - c.* Note the fleshy "*auricular appendages*"—one (*left*) appearing below the pulmonary artery; the other (*right*) between the aorta and superior cava.
  - d.* Placing the heart and its vessels as nearly as you can in their natural positions, sketch them as seen from the front.
8. Dissect away very carefully the collection of fat around the origins of the great arterial trunks and that around the base of the ventricles. In the fat will be found—
  - a.* A *coronary artery* arising from the aorta close to the heart, opposite the right border of the pulmonary artery; it gives off some branches to the auricles, and then runs down the heart behind the ventricles.
  - b.* The other *coronary artery* considerably larger, arises from the aorta behind the pulmonary artery, and is distributed also, to both auricles and ventricles.
  - c.* The *coronary veins* and *sinus*: small coronary veins will be seen accompanying the arteries: for the coronary sinus see hereafter (9. *c.*)

9. Open the right ventricle by passing the blade of a scalpel through the heart about an inch from the upper border of the ventricle and on the right of the band of fat marking externally the limits of the ventricles, and noted above (7. *b*), and then cut down towards the apex, keeping on the right of this line : cut off the pulmonary artery about an inch above its origin from the heart, and open the right auricle by cutting a bit out of its wall, to the right of the entrances of the *venæ cavæ*. By raising up by its point the wedge-shaped flap cut from the wall of the ventricle, the cavity of the latter will be exposed.
  - a.* Pass the handle of a scalpel from the ventricle into the auricle ; and also from the ventricle into the pulmonary artery, and make out thoroughly the relations of these openings.
  - b.* Slit open the auricular appendage : note the fleshy projections (*columnæ carneæ*) on its walls, and the smoothness of the rest of the interior of the auricle. Observe the apertures of the *venæ cavæ*, and make sure that the pulmonary veins do not open into this auricle.
  - c.* Behind or below the entrance of the inferior cava, note the entrance of the *coronary sinus* : pass a probe through the aperture along the sinus and slit it open : notice the muscular layer covering it in.
10. Raise up by its apex the flap cut out of the ventricular wall, and if necessary prolong the cuts more towards the base of the ventricle until the divisions of the *tricuspid valve* come into view.
  - a.* Note the *columnæ carneæ* on the wall of the ventricle, and the muscular band stretching across its cavity. Also the prolongation (*conus arteriosus*) of the ventricular cavity towards the aperture of the pulmonary artery.
  - b.* Cut away the right auricle and examine carefully the *tricuspid valve* : composed of three membranous flexible flaps, thinning away towards their free edges, at present turned towards the ventricle : proceeding from near these edges are strong

*tendinous cords* (*chordæ tendineæ*) which are attached at their other ends to muscular elevations (*papillary muscles*) of the wall of the ventricle. Draw one of the flaps with its cords and papillary muscle.

c. Slit up the *conus arteriosus* until the origin of the pulmonary artery comes into view. Looking carefully for the flaps of the semilunar valves, prolong your cut between two of them so as to open the bit of pulmonary artery still attached to the heart. Spread out the artery and examine the valves. Draw them.

d. Each flap makes, with the wall of the artery, a pouch, opposite which the arterial wall is slightly dilated. The free edge of the valve is turned from the heart, and has in its middle a little nodule (*corpus Aurantii*.)

11. Open the left ventricle in a manner similar to that employed for the right. Then open the left auricle by cutting a bit out of its wall above the appendage. Cut the aorta off about half an inch above its origin from the heart. The aperture between left auricle and left ventricle can now be examined; also the passage from the ventricle into the aorta, and the entry of the pulmonary veins into the auricle; and the *septum* between the auricles and that between the ventricles.

a. Pass the handle of a scalpel from the ventricle into the auricle; another from the ventricle into the aorta: and pass also probes into the points of entrance of the pulmonary veins. Observe that no other veins open into this auricle.

b. Slit open the auricular appendage: note the fleshy projections (*columnæ carneæ*) on its interior, and the general smoothness of the rest of the inner wall of the auricle. Notice the *columnæ carneæ* over the inner surface of the ventricular wall: also the considerable thickness of the latter, as compared with that of the right ventricle or of either of the auricles.

- c. Carefully raise the wedge-shaped flap of the ventricle and cut on towards the base of the heart, until the valve (*mitral*) between auricle and ventricle is brought into view : one of its two flaps will be seen to lie between the auriculo-ventricular opening and the origin of the aorta.

Examine in these flaps their texture, the chordæ tendineæ, the columnæ carneæ, &c., as in the case of the right side of the heart (10.)

- d. Examine *in situ* the semilunar valves at the exit of the aorta ; then cutting up carefully between two of them, examine the bit of aorta still left attached to the heart, and examine the valves more carefully as described in 10. d. Note the origins of the coronary arteries in two of the three dilatations (*sinuses of Valsalva*) of the aortic wall above the semilunar flaps.

12. Study, with the assistance of demonstrator, the action of the valves in the dead heart.

#### IV.

##### STRUCTURE OF BLOOD VESSELS. BEAT OF THE HEART.

1. Examine the piece of artery provided for you ; note that, although empty, it does not collapse ; the thickness of its wall ; its elasticity in all directions.
2. Examine with your microscope, and sketch —
  - a. The prepared transverse sections of arterial wall ; note the three primary coats entering into its structure.
  - b. The specimen prepared to show the epithelial cells lining the interior of an artery.
3. Note in the vein provided for you ; its collapsed state and the thinness and flaccidity of its wall compared with the arterial ; its slighter elasticity. Observe, however, that the differences between these smaller arteries and veins are much less marked than those between the great arteries and veins in the neighborhood of the heart, which you examined last week.

4. Cut the vein open : examine and sketch its valves.
5. Examine with your microscope (Oc. 4, Obj. A) the prepared specimen of *pia mater* : note the nuclei of the transverse muscular cells of the arteries (sometimes the outlines of the individual *contractile fibre* cells can be seen); the capillaries into which the arteries break up ; the thin walls of these capillaries, on which here and there, however, a nucleus may be seen. Draw a bit of one of the arteries and a portion of the capillary network.
- [6. Examine injected specimens showing the arrangement of the capillaries in various tissues.]
7. Take the frog provided for you : it has, while under the influence of chloroform, had its brain and spinal cord destroyed. Laying the animal on its back, carefully divide with scissors the skin along the middle line of the ventral surface for its whole length. Make cross cuts at each end of this longitudinal one and pin out the flaps of skin.

Next pick up with your forceps the tissues forming the remainder of the ventral wall near its posterior end, and carefully divide them longitudinally a little on the left side of the middle line ; being very careful not to injure either the viscera in the cavity beneath or a large vein (*anterior abdominal*) running along the wall in the middle line.

About the point where you see this vein turning away from the wall to enter among the viscera in the ventral cavity, you will come to the bony and cartilaginous tissues of the sternal region. Raise the posterior cartilage in your forceps, make a short transverse cut in front of the vein and, looking beneath the sternum, note the pericardium with the heart beating inside it. Divide the fibrous bands which pass from the pericardium to the sternum, and with your larger pair of scissors divide the latter along the median line.

Commencing at your short transverse cut, make a longitudinal incision extending backwards a little on the right of the middle line, so as to leave the anterior abdominal vein intact with a



narrow strip of the belly wall over it; make cross cuts at the ends of the longitudinal ones, and pin out the flaps on each side. Cut away entirely the halves of the sternum, taking great care not to injure the vessels beneath.

Push a piece of glass tubing down the animal's throat so as to stretch the parts, and picking up the pericardium in your forceps, open it and gently cut it away from about the heart; push aside any lobes of the liver which lie on the latter organ. In the heart thus exposed, note —

- a.* Its *beat*; a regularly alternating contraction (*systole*) and dilatation (*diastole*).
  - b.* In consequence of the destruction of the spinal cord comparatively little blood now flows through the heart, but during the contraction you will be able to observe that the ventricular portion, which will be readily recognized, becomes paler; and during diastole again becomes deeply colored, getting more or less filled up with blood which shows through its walls.
  - c.* Observe that each contraction starts at the auricular end and travels towards the ventricular; this may be more easily seen by-and-bye when the heart begins to beat more slowly.
8. The frog's heart differs in certain structural points from that of the sheep. Some of these may be noted as follows:
- a.* Passing a blunt hook carefully beneath the ventricle, raise it up. Beneath it will be seen a pulsating portion of the heart (*sinus venosus*), not separately recognizable in the sheep's heart. This cavity receives the venous blood from the systemic circulation and transmits it to the right auricle; notice opening into it, at its posterior end, the inferior vena cava, and on each side a vein which, roughly speaking, answers to a superior vena cava.

- b. Returning the ventricular portion of the heart to its natural position, observe that from it a distinct aorta and pulmonary artery do not arise, but instead a pulsating sac (*bulbus arteriosus*) which lies in front of the auricles.
- c. A short way from the heart this sac divides into two main arterial stems, the *right* and *left aortic arches*, each of which soon divides into three vessels. Observe these branches in the prepared specimen, and then carefully clean them in your own. The most anterior (*carotid trunk*) ends in a small red or black body, from which vessels arise which supply the head. The next (*aortic arch proper*) after giving off a branch which supplies the fore limb on its own side, runs back to beneath the vertebral column, where it joins its fellow to form the *dorsal aorta*. The third (*pulmono-cutaneous*) first gives off a branch which runs to the skin of the dorsal region, and then enters the lung on its own side.
- d. Opening into the left auricle is a *pulmonary vein*, formed by the union of the single pulmonary veins from each lung.
- [e. Make a transverse section of the main aortic stem which has been imbedded in paraffin mixture (Paraffin 2 parts, Vaseline 1 part); transfer your section to a slide, dissolve away the excess of paraffin with carbolic acid and turpentine, and examine with Oc. 2, Obj. A. Observe that the arch is subdivided by partitions into three channels, answering to the three trunks into which it ultimately divides.]

Note that each beat of the heart commences with a contraction of the sinus venosus, and that this is followed in order by contraction of the auricles, the ventricle, and the arterial bulb.

Draw the heart and main vessels as seen from the ventral side.

11. Divide the vessels passing to or from the heart at a short distance from the organ. Take one of the aortic arches in a pair of forceps, and raising the heart, divide any remaining bands which attach it to the rest of the body, and transfer it to a clean microscope slide. Observe that it still continues to beat; if the beat stop at first, it will be resumed in a few seconds.
12. With a clean sharp razor divide the heart across the middle of the ventricle and examine the interior of the latter. It is not divided into two distinct chambers, but is spongy, containing numerous intercommunicating cavities.
- [13. Examine the prepared specimen which shows the partition between the two auricles.
14. With your razor cut the upper portion of the divided heart into a number of pieces. Note that many of these still continue to beat, or recommence beating after a short time, and that when the spontaneous beat has ceased, a contraction can be excited in many of them by a gentle prick with a microscope needle.
- [15. Examine the specimen which has been prepared to show the nerve cells in the partition between the auricles.]
16. Observe, with the assistance of the demonstrator, the beat of the heart in the narcotized rabbit, the chest of which has been opened, and in which artificial respiration is kept up. Note—
  - a.* The rhythmically alternating contractions and dilations.
  - b.* Endeavor to make out that the auricular systole just precedes the ventricular; this becomes easier to observe as the heart begins to beat slower.
  - c.* Observe that both sides of the heart work synchronously: both auricles contract together and both ventricles together.
  - d.* Gently take the ventricular portion of the heart between your finger and thumb. Feel how it hardens and forcibly takes its new form during the systole.

## V.

## THE CIRCULATION OF THE BLOOD.

1. Take the frog provided for you, which has been narcotized by chloral, and lay it, belly downwards, upon the frog-board. Gently tie strings around the two middle toes, and passing them through the slits in the board, spread out the web between the two toes over the V-shaped notch in the board. Be very careful not to stretch the web. Put a piece of wet blotting paper over the back of the animal, and place the board on the microscope stage so that the spread-out part of the web is over the aperture. Examine with Oc. 2, Obj. A. Notice —

- a. The skin with the pigment cells in it — these may be contracted into little very black patches or be expanded and less deeply colored; then focus through the skin and make out—
- b. The *arteries*, in which the blood flows faster than elsewhere, and from larger to smaller vessels, and in which the flow has for the most part a direction towards the free edge of the web.
- c. The *capillaries*, receiving the blood from the arteries and forming a network in which all the vessels are of about the same size, so that there is no alteration in diameter at the points of division, as in the arteries which become smaller as they branch.
- d. The *veins*, which arise by the union of capillaries, and in which the flow is from smaller to larger branches, and on the whole slower than in the arteries but faster than in the capillaries.
- e. In the larger arteries in view the flow may not be quite continuous, but present rhythmic accelerations corresponding to the beats of the heart; but if the web has been properly spread out and the heart is acting

vigorously, the flow will be quite continuous in the smallest arteries, as also in the capillaries and veins

2. Put on your Oc. 4, and note—

- a. That in the arteries and veins the blood flows faster in the centre of the vessels than towards the sides, and that all the red corpuscles are carried along in this *axial stream*; while in immediate contact with the vascular wall there is a layer (*inert layer*) in which the flow is very slow, and where there are no red corpuscles, but where numerous white corpuscles will be seen, getting along much more slowly than the corpuscles in the axial stream.
- b. Observe attentively the circulation in the capillaries: you will readily see evidences of the elasticity of the red corpuscles; they are frequently distorted by mutual pressure; or you may find one debouching from the end of a capillary whence two others proceed at about equal angles, pulled out to a great length by the diverging currents until one or the other current gets the better, and the corpuscle carried away by it immediately resumes its normal form.

3. Sketch a portion of the vascular network.

4. Put on your Oc. 2 and Obj. D, and study more carefully the flow in the capillaries.

5. Observe the circulation in the mesentery of the frog: there being here a much smaller quantity of other tissues present to obscure the view, the flow in the capillaries will be much better seen: the axial stream and inert layer will also be more easily seen, especially in the veins. However, inflammatory changes soon supervene and interfere with the natural circulation. Having finished with your frog, destroy its brain and spinal end to prevent its returning to consciousness when the influence of the chloral passes off.

6. Study, with the assistance of the demonstrator, the outflow of liquid which is injected intermittently into—

- a.* A rigid tube with free exit.
- b.* A rigid tube with some resistance to the outflow.
- c.* An elastic tube with free exit.
- d.* An elastic tube with resistance to the outflow.

The outflow in *a*, *b*, *c*, will be intermittent ; in *d*, continuous, but with slight accelerations at each stroke of the pump ; therefore an elastic tube, with resistance to the flow at one end, transforms into a constant current an intermittent supply of liquid pumped into its other end fast enough to keep its walls distended.

7. Study, with the assistance of the demonstrator, the circulation in the larger arterial scheme ; observe the general arrangement of the apparatus.

- a.* It consists of a pump by which water is intermittently sent into an elastic tube, which with its branches represents the arterial system. The branches end in small tubes, blocked with sponge, which represent the capillaries, and these open into larger tubes which unite and represent the venous system, from which the water finally passes out. There are also connections by which the fluid can pass directly from the arterial to the venous side without experiencing any capillary resistance.
- b.* Connected with an arterial and a venous tube are mercury pressure gauges which will indicate the pressure of the fluid in the vessels connected with them, and any alterations in this pressure.
- c.* On an arterial and on a venous tube are levers (pulse levers) arranged so as to indicate any changes in the diameters of the tubes.



8. Observe when the pump begins to work, the direct communications between the arterial and venous sides being open, that with each stroke of the pump there is a sudden and great rise of pressure in both arteries and veins, and that the pulse levers on both are set in movement. Between each stroke of the pump the pressure returns on both sides to its original level, so that there is no steady "arterial pressure."
9. When the direct communication is partly closed, observe that the pressure on the arterial side does not sink to zero between each stroke of the pump, but as indicated by the gauge some arterial pressure still remains in the intervals, though greatly increased rhythmically with each stroke. At the same time the pulse on the venous side becomes less marked.
10. As the resistance to the flow from the arterial to the venous side is increased by shutting off all the direct communications, and making all the water pass through the sponge-blocked tubes, the average arterial pressure rises, and each individual pulse beat in the arteries is less marked. The pressure in the veins does not rise, and the pulse beats there disappear entirely. The state of things in the scheme now approximately represents that in the blood vessels of the body: there is a constant high pressure on the arterial side, slightly increased (and manifesting itself as the pulse) at each stroke of the supplying pump. This pressure is maintained by two factors, the supply from the pump and the resistance to the outflow presented by internal friction in the smaller vessels. The distended elastic tubes exert a continuous pressure on the fluid within them, and drive it steadily through the smaller tubes and the larger ones into which these again open. The intermittent beat is thus transformed into a continuous squeeze, and so arises the steady flow through arteries and veins and the absence of a pulse in them.

11. When the resistance to the flow from the arterial to the venous side is still farther increased by completely occluding some of the tubes representing capillaries, observe that the mean arterial pressure rises higher, while the individual pulse beats become still less marked. No change will be observed on the venous side.
12. The resistance remaining the same, observe that with an increased rapidity of the strokes of the pump, the mean arterial pressure rises.
13. When the narrow mouthed glass tubes connected, one with a branch on the arterial side and another with a branch on the venous side, are opened, observe how the water spurts with force out of the tube on the arterial, but flows out gently on the venous side.
14. When colored liquid is introduced into the pump, observe that the increase of pressure in the arteries following each stroke of the pump (*i. e.* the *pulse wave*) travels far faster than the liquid; the pulse lever rises very quickly after the stroke, but it will not be until after several strokes that the colored fluid (as seen in the intercalated piece of glass tubing) will reach the neighborhood of the lever.
15. Repeat for yourselves the experiments with the arterial scheme.

## VI.

### SOME NERVES REGULATING THE CIRCULATION OF THE BLOOD, EITHER GENERALLY OR LOCALLY.

1. Spread out, upon its back, the dead rabbit provided for you; fix it by driving a tack through each paw.

Make an incision through the skin in the middle line from the front of the lower jaw to the posterior part of the chest; make a cross cut at each end of this longitudinal one, and reflect the flaps of skin thus marked out.

2. In the middle line of the neck you can now see and feel, through a thin covering, the trachea and larynx. On each side, a short way behind the angle of the lower jaw, you will see the large *external jugular vein* formed by the union of two veins (*anterior and posterior facial*) from the head region.

Between the trachea and the external jugular vein, on each side, you will see a muscle (*sterno-mastoid*) meeting its fellow in the middle line near the root of the neck, but diverging from it further forwards.

3. Clear away carefully, on the left side, the thin muscular and connective tissue layer (*platysma myoides*) through which the parts above mentioned have hitherto been seen: take special care not to prick the jugular vein and so get blood over your dissection; if any small branch of the vein has to be cut, tie it first. On the median border of the sterno-mastoid, opposite the anterior part of the trachea, will now be seen another muscle (*sterno-hyoid*) appearing between the sterno-mastoid and the trachea.
4. Carefully separate the sterno-mastoid from the sterno-hyoid, pulling the former outwards and tearing through the connective tissue between the two muscles with the back of a scalpel. By this means will be brought into view the *common carotid artery* and certain nerves.
5. Divide the sterno-mastoid at its sternal attachment, and turn it forward out of the way. Taking hold of the carotid artery in your forceps, gently raise it, and carefully separate it from the nerves and other adjacent tissues, from its entry into the neck until it divides, opposite the angle of the lower jaw, into the *internal* and *external carotid arteries*. Notice a small nerve (*superficial cervical*) which crosses over the artery opposite the posterior border of the larynx.
6. Trace the external carotid artery forwards: it soon divides into several large branches. To see these it will be necessary to

turn outwards the *submaxillary gland*, a soft roundish mass about the size of a small hazel nut, lying inside the ramus of the lower jaw near its angle. Especially trace out the branch (*external maxillary*) of the external carotid which passes on to the face, turning round the jawbone. As it passes the submaxillary gland it gives off one or two branches to that organ. Alongside these branches veins pass out of the gland and join a trunk which ultimately opens into the anterior facial vein. The slender duct of the gland will also be seen passing inwards and forwards, and in the present position of the parts (with the gland turned outwards), crossing over the external maxillary artery. The large *hypoglossal nerve* will also be seen passing inwards across the divisions of the external carotid; and running parallel to the nerve, the tendon of the *mandibular muscle*, (anterior belly of the *digastric* of man.)

7. Trace back the carotid artery to the root of the neck until it passes beneath the external jugular vein, or rather a branch uniting that vein with its fellow across the middle line.
8. Next follow the *pneumogastric nerve*, which, taking the same course along the neck as the artery did, will be readily recognized by its whiteness and considerable size. The smaller, less white nerve lying alongside the pneumogastric is the *cervical sympathetic*; and running close beside the posterior half of the cervical sympathetic is another still finer nerve, the *depressor*.
9. Carefully dissect out the pneumogastric and its branches in the neck, taking care not to injure the other nerves.

Shortly after appearing through an aperture in the base of the skull, the nerve will be seen to be crossed by the hypoglossal: a little lower down it presents an oval enlargement (*ganglion nodosum*).

From thence the nerve runs down the neck, crossed by the superficial cervical, and sending inwards a branch (*superior*

*laryngeal*) which arises at about opposite the point of division of the common carotid artery and passes inwards beneath that vessel. Just above this point some small *pharyngeal branches* may be seen to arise, but they are not of importance for our present purpose. On the other hand great care must be taken not to injure a very small branch (*cardiac branch*) which usually is to be found arising from the nerve, a little farther back in the neck than the superior laryngeal.

10. A small branch will be found arising from the superior laryngeal nerve, close to the main pneumogastric trunk : it runs back in the neck, and joining the cardiac branch of the pneumogastric (when present), the two form the slender nerve (*depressor nerve*) which runs down the neck alongside the sympathetic trunk : very carefully separate it from this latter and trace it to the root of the neck.
11. Taking the cervical sympathetic about the middle of its course in your forceps, gently raise it and follow it forwards : near the skull it will be seen to possess an elongated ganglion (*superior cervical ganglion*), from which numerous branches are given off. Follow the nerve back along the neck until it passes beneath the external jugular vein.
12. Appearing in the neck external to the line of the pneumogastric and sympathetic, will be seen the *anterior primary branches* of the cervical spinal nerves. The superficial cervical nerve arises from one of these. Arising from the hypoglossal trunk near where it crosses the pneumogastric, will be seen the *descending branch*, which is united by branches with the pneumogastric and the superficial cervical.
13. Try and find an extremely fine nerve (*chorda tympani*) which lies alongside the duct of the submaxillary gland.
14. Cut across the muscles passing from the chest towards the shoulder on both sides, near their thoracic attachments, and

turn them outwards. The arteries, veins and nerves passing between the trunk and the fore limbs, will now be exposed ; also the rudimentary collar-bones of the rabbit. Dissect out on the left side the junction of the vein from the arm (*subclavian*) with the external jugular. Pass two ligatures around the external jugular close to its union with the subclavian, divide it between the ligatures, turn it up out of the way, and dissect out a ganglion (*ganglion stellatum*) which exists on the sympathetic trunk at the bottom of the neck.

15. Make a diagram of the nerves of the neck ; and draw the sub-maxillary gland with its vessels, duct, and nerve.
  
16. Take hold of the front end of the sternum in your large forceps, and raising it, cut through the muscles and rib cartilages on each side of it ; turning the breast bone backwards, cut it across with your large scissors, just in front of the posterior boundary of the chest cavity, and remove it entirely. Through the opening thus made you will see the diaphragm, convex towards the chest cavity and separating it from the abdomen. Attached to the diaphragm is the pericardium, through which the heart can be seen ; lying at the back of the cavity, on each side, will be found a collapsed lung. Remove the chest wall, on both sides, except about an inch next the vertebral column. The *phrenic nerves* will now be seen running on each side from the neck to the diaphragm. Pull the heart and left lung over to the right side, and fix them there. Trace the trunk (*left superior cava*) formed by the union of the left subclavian with the left external jugular vein on toward the heart. Put two ligatures around the subclavian vein near the shoulder, and divide it between them : ligature and divide similarly the left superior cava near the heart, and then cut away both these veins and dissect out the origin of the phrenic nerve from some of the branches of the cervical spinal nerves. Remove the *thymus gland* lying at the top of the chest in the middle line, and dissect out

cautiously the left common carotid artery down to its origin from the aortic arch.

17. Taking up the vagus (pneumogastric) where you left it at the base of the neck, follow it down through the thoracic cavity: opposite the lower border of the arch of the aorta it gives off a branch, the *inferior* or *recurrent laryngeal nerve*, which turns back under the arch of the aorta. The main trunk passes on behind the root of the lung, giving off some small *bronchial* branches, and finally gets on to the gullet, along with which it passes through the diaphragm.
18. Cut away the *ligamentum arteriosum*, and dissect out the recurrent laryngeal nerve near its origin; from it about that point arise some small *cardiac branches*, which can be traced into the tissue behind the heart: the farther course of the nerve, which runs back to the larynx, need not now be followed.
19. Dissect out carefully the inferior cervical ganglion (*ganglion stellatum*) of the sympathetic: from it numerous branches will be seen to arise, some of which pass in towards the heart; of the others, one branch passes in front of, another behind the subclavian artery, and the two unite beyond it to form the commencement of the thoracic sympathetic cord: cut away the subclavian artery and follow this cord down through the chest, pushing the diaphragm down out of your way.
20. The *thoracic sympathetic trunk*, continuous in front with the cervical, runs along the chest cavity, outside the pleura, a short way from the bodies of the vertebræ, and crossing the ribs near their attachments to the vertebral column. Opposite each rib the cord presents a ganglion: these ganglia are connected by branches with the neighboring intercostal nerves. In the posterior part of its course the nerve lies on the median side of the *psoas major muscle*, which passes into the abdomen behind the diaphragm.

21. From the 8th, 9th, or 10th thoracic ganglion, counting from the front, notice that a nerve, the *splanchnic*, arises: running back, it gets branches from the ganglia posterior to its origin, and then passes into the abdominal cavity through the diaphragm and close to the aorta.
22. Very carefully trace the depressor nerve into the tissue about the base of the heart.
23. Having now learnt what to look for, repeat your dissection on the right side of the neck and chest. The main difference you will come across will be, that on this side the recurrent nerve curls back around the subclavian artery, and not around the arch of the aorta, and the common carotid and subclavian arteries do not arise directly from the arch of the aorta, but are formed by the bifurcation of a short common trunk, the *innominy*.
24. Divide the skin along the middle ventral line of the belly from the thorax to the pelvis: make a cross cut at the posterior end of this one, and reflect the flaps of skin. Now divide the muscles of the belly wall similarly, taking care not to injure the viscera in the cavity. Cut through the walls of the belly on each side below the attachment of the diaphragm, from the middle line in front to near the vertebral column, and reflect the flaps thus formed.
25. Pushing the stomach, intestines and liver over to the left side, trace the right splanchnic nerve into the abdomen, tearing through any mesenteric folds which are in the way. The nerve lies a little to right of the aorta and can be traced into a large ganglion (*upper celiac ganglion*) which lies in the mesentery: from this ganglion and another (*lower celiac ganglion*) near it, numerous branches pass off, which unite the two ganglia and radiate in the neighboring mesentery: most of them pass to the abdominal viscera along the blood-vessels. The left

splanchnic nerve enters the abdomen close on the left side of the aorta ; its final distribution is much like that of the right.

26. Trace the two pneumogastrics along the gullet on to the stomach, and then pass two ligatures around the gullet on the abdominal side of the diaphragm, and divide it between the ligatures.

27. Find the rectum in the pelvis, pass two ligatures around it and divide it similarly. Raise up the liver and find on its under (posterior) side the large *portal vein* entering it ; put two ligatures around the vein and divide it between them. With your scissors divide the thin membrane (*mesentery*) by which the parts of the alimentary canal are slung, and then remove the stomach and intestines *en masse*.

28. The kidneys will now be seen, with the duct (*ureter*) passing back from each to the pelvis. Anterior to the kidneys and nearer the middle line lie two whitish masses, the *supra-renal capsules*. In the middle line will be seen the abdominal aorta giving off among others a branch (*renal artery*) to each kidney. Alongside the aorta is the *inferior vena cava* which receives the *renal veins*.

29. Tie the inferior vena cava with two ligatures close above the diaphragm, and similarly a little way behind the liver. Divide it between each pair of ligatures, and then, cutting through any bands which attach the liver, remove it. Cut away the ring of the body wall to which the diaphragm has been left attached, except its dorsal fourth, and remove also all the diaphragm except the portion of it near the vertebral column.

30. Now follow the sympathetic trunks down through the abdominal cavity. They lie near the middle line at the back of the cavity, and present ganglia at intervals as in the thorax. The two trunks posteriorly become very slender, but by removing the front of the pelvis, the rectum, and the urinary bladder, they

may, with care, be traced until they unite in a single ganglion in front of the third caudal vertebra. In their course the ganglia on the nerves give off branches which run on the aorta and its branches to the abdominal viscera, being united with numerous accessory ganglia in the mesentery and elsewhere, but the dissection of these fine branches is too difficult to be undertaken in a class.

*Demonstration of blood pressure in the carotid artery.*

1. Observe in the narcotized rabbit the pressure in the carotid artery, as indicated by the mercury gauge connected with it.
2. Note the trace marked by the pen on the travelling paper: it indicates that the pressure is not constant, but presents variations of two kinds: the slower variations agreeing in rhythm with the respiratory movements; the smaller (*pulse waves*) and more numerous, with the beats of the heart. Measure the average pressure as indicated by the mercury.
3. Note the chronograph, which marks seconds on the travelling paper.
4. Note the lower pen which marks the line of no pressure.

*Influence of the pneumogastric nerve on the heart's beat and on the blood pressure.*

1. When both pneumogastric nerves are divided, notice that the pulse waves become more numerous in a given time, indicating that the heart is beating more quickly.
2. When the distal end of one pneumogastric nerve is stimulated feebly, notice that the heart's beats become slower, and the blood pressure falls.
3. When the nerve is stimulated more strongly, notice that the heart's beats, as indicated by the tracing, stop altogether for a time, and the blood pressure falls very greatly and suddenly almost to zero.

4. When the heart begins to beat again, the blood pressure quickly rises to quite, or a little more than, its original level.

*Demonstration of the action of the pneumogastric nerve upon the heart of the frog.*

1. Observe the beat of the heart in the narcotized frog: it is regular, and fairly powerful.
2. When the pneumogastric trunk on one side is directly stimulated, observe that the heart ceases to beat for a short time.
3. When the intestines are smartly tapped in another frog, notice that the heart also temporarily ceases to beat.
4. After the pneumogastric nerves of this second frog have been divided, observe that the heart's beat is not affected by a blow on the intestines.
5. It can be shown by other experiments that the stimulus produced by striking the intestine travels into a part of the sympathetic chain; from there by some of the communicating branches with the spinal nerves into the spinal cord, and along it to the origin of the pneumogastrics in the brain, where it is *reflected* down those nerves to the heart.

*Demonstration on blood pressure as affected by the dilatation of the arteries.*

1. When the depressor nerve is divided in the neck of the chloralized rabbit, notice that the blood pressure (in the great majority of cases) remains unaffected.
2. When the central end of the nerve is stimulated, notice that shortly the average blood pressure begins to fall; gradually diminishes to a certain level, and there remains constant, except for the respiratory and pulse variations noted above.
3. When the stimulation of the nerve is stopped, notice that the average blood pressure soon begins to rise, and slowly regains its former level.

4. It can be shown by other experiments, too complicated for demonstration here, that the fall of blood pressure on stimulation of the depressor nerve is mainly due to a dilatation of the arteries of the abdominal viscera, brought about through the splanchnic nerves.

*Demonstration on blood pressure as affected by increase of the resistance to the flow through the arteries.*

1. When the abdominal aorta of the chloralized rabbit is compressed, notice that the mean blood pressure in the carotid, as indicated by the arterial gauge, rises. This is due to the greater resistance met with by blood in its flow, it now having fewer arterial paths open to it than before.
2. As the pressure rises the heart beats slower: this can be shown to be mainly a secondary effect, due to irritation of the central ends of the pneumogastrics by the increased blood pressure in the brain.
3. When the pressure is removed, the mean blood pressure returns to its former level.

*Demonstration on the vaso-motor nerves of the skin.*

1. Notice in the narcotized rabbit that both its ears, when looked through against the light, are about equally full of blood, and that they both feel about equally warm to the touch.
2. After the sympathetic nerve has been divided on one side of the neck, notice that the vessels of the ear on that side are (usually) dilated and gorged with blood; the whole ear is redder and feels hotter than the other.
3. When the cephalic end of the cut sympathetic is stimulated, notice that the arteries of the ear gradually contract, until finally they allow little or no blood to pass, and the whole ear becomes cold and very pale.

4. When the stimulation is stopped, notice that the arteries soon dilate, and the ear becomes again gorged with blood.

*Demonstration on the vaso-motor nerves of a gland.*

1. Notice in the narcotized animal that a glass tube has been passed into the duct of the submaxillary gland. The saliva seen at the bottom of the tube is not now rising in it, showing that the gland is not secreting.
2. Another glass tube has been arranged to collect the blood flowing out of the veins of the gland: at present it is small in quantity and dark in color.
3. When the nerve of the gland is stimulated, notice that it begins to secrete rapidly, and that the blood goes to it now in much larger quantity, as indicated by the greater quantity passing out through the vein, and by its brighter color.
4. The gland nerve contains fibres which excite its secreting cells to activity, and also fibres which bring about a relaxation of the walls of the artery supplying it, so that the working cells get a greater blood supply.

*Repetition of some of the above on the arterial schema.*

1. Go to the arterial schema; connect a mercury gauge, a float and a pen, with a tube on the arterial side, and make the pen write on a revolving cylinder.
2. Having got a regular pump stroke and a constant average pressure, imitate (*a*) the effect of cutting the pneumogastric nerves; (*b*) the effect of stimulating the peripheral pneumogastric feebly and strongly; (*c*) the effect of stimulating the central end of the depressor nerve; (*d*) the effect of compressing the abdominal aorta.

## VII.

## RESPIRATION.

1. Examine the prepared skeleton of the human thorax: formed by the twelve dorsal vertebræ behind; the breast bone (*sternum*) in front; and twelve ribs, with their cartilages, on each side.
2. The sternum is flattened dorso-ventrally, and consists (in the adult) of three pieces: the upper piece (*manubrium*) is wider than the rest, and also thicker; to its sides are attached the cartilages of the first pair of ribs; above the attachment of each rib is a notch, into which the ventral end of the collar bone of the same side was originally articulated.
3. The middle segment or *body* of the sternum presents on its ventral surface three transverse ridges, indicating the points of junction of the separate pieces of which it originally consisted. To its sides are attached the third, fourth, fifth and sixth rib cartilages on each side, and at its point of junction with the manubrium the second rib cartilage.

The remaining segment of the sternum (*ensiform process, xiphoid cartilage*) is often incompletely ossified. To it no rib is attached.

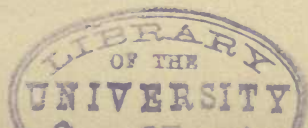
4. Examine the fifth rib: a slender, curved, elastic bone, presenting a dorsal thickened extremity or capitulum, attached to the bodies of the fourth and fifth dorsal vertebræ; a little way from the head is an enlargement (*tubercle*) attached to the transverse process of the fifth dorsal vertebra. To the ventral end of the bony rib is attached a *rib cartilage*, which continues the rib forwards, and is fixed to the side of the body of the sternum. From the tubercle the rib curves round to the cartilage; the part where the curvature is most marked being called the *angle* of the rib. Note the groove on the under border of the rib, especially marked near the angle; in this the intercostal vessels and nerves formerly lay.

5. Compare the other ribs with the fifth and with one another. The first rib is shorter and broader than the rest, and its *head* is attached to only one (first dorsal) vertebra. On its upper surface are roughnesses, marking the attachment of certain muscles (*middle* and *anterior scaleni*). From the first the ribs increase in length to the eighth and then diminish again. The cartilages of the sixth and seventh ribs are attached together to the sternum. The eighth, ninth and tenth rib cartilages are not attached directly to the sternum, but each to the rib cartilage above it. The cartilages of the eleventh and twelfth (floating) ribs are not attached directly or indirectly to the sternum.
6. The thorax as a whole is somewhat conical in form, being wider below than above, and also from side to side than dorso-ventrally. The ribs as a rule do not lie in a horizontal plane, but the middle portion of each is at a lower level than a straight line joining the two ends, and the ventral end is lower than the dorsal.
7. Observe that, by reason of the elasticity of the ribs, their mode of articulation to the vertebral column, and the pliability of the rib cartilages, a certain amount of movement is possible to each of them, so that they (with the sternum) can be raised or lowered a little on the vertebral column, and can rotate to a certain extent around an axis joining their dorsal and ventral attachments.
8. Take the rabbit provided for you (from which the abdominal viscera, except the liver and kidneys, have been removed), and dissect away the skin from the front and sides of the neck and chest; remove the platysma (VI. 3), and also a fibrous membrane which covers the chest under the skin.
9. Divide at their sternal attachments and turn outwards, the muscles now seen passing from the chest to the shoulder. The larger of these, fan-shaped, is the *pectoralis major*; the smaller (*pectoralis tenuis*), a ribband-like muscle lying along the anterior edge of the great pectoral, is not a distinct muscle in man. The vessels and nerves of the fore limb will now be seen passing outwards over the border of the first rib.

10. There will now be exposed on the chest-wall anteriorly the pectoralis minor, like the great pectoral in shape but smaller; behind this is seen another muscle (*serratus anticus major*), which arises by zig-zag processes attached to the ribs, from the third to the ninth, at the junction of the bones with the rib cartilage. Interdigitating with the processes of the serratus, thoracic attachments of the descending oblique muscle will be seen: divide all these muscles and turn them out of the way. The external intercostal muscles will then be exposed for the greater part of their course; but near the spinal column they will be covered by another muscle, the *longissimus dorsi*; in part also by the rhomboideus passing from the neck to the scapula; also in front by the *scalenus medius*.
11. Divide and remove the sterno-mastoid and sterno-hyoid muscles (VI. 3): also the sterno-thyroid, which arises on each side from the back of the manubrium of the sternum along with the sterno-hyoid, and passes thence forwards along the side of the trachea, to be inserted into the thyroid cartilage.
12. Dissect out the muscles passing from the neck to the ribs: they will be seen easiest first at their rib attachments; the *scalenus anticus* arises from the transverse processes of the cervical vertebræ from the fourth to the seventh, and is inserted into the first rib, near its cartilage; the *scalenus medius* arises by a tendon from the transverse process of the fifth cervical vertebra, and spreading out below, is inserted into the third, fourth and fifth ribs; the *scalenus posticus*, arising from the transverse processes of the fourth, fifth and sixth cervical vertebræ, is inserted into the first rib.
13. Separate, in front of the larynx, the muscles and other organs which occupy the space between the rami of the lower jaw. The hyoid bone, to which the larynx is attached, will be thus brought into view.
14. Note the thyroid body lying on the sides of the trachea close to the larynx: cut the wind-pipe across just beyond the thyroid body; and divide similarly the *gullet*, a muscular tube which will be found lying immediately on the dorsal side of the wind-pipe.

15. Open the rabbit's mouth as widely as possible, cutting through any muscles, &c., which interfere with the separation of the jaws, and then disarticulate or break the lower jaw, so as to get a good look into the pharynx.
16. Pull the tongue forwards; at its root will be seen the tip of the whitish epiglottis; taking hold of it with your forceps, raise it and pull it forwards; the aperture of the glottis will then be seen; a probe passed down it comes out of the divided trachea lower down. Pass another probe down the throat behind the glottis; it appears through the divided gullet.
17. Examine the diaphragm from its exposed abdominal side: it is concave towards the abdomen; tendinous and transparent in the centre, allowing the lungs to be seen through it, but muscular and somewhat less transparent on the sides, but still allowing the lungs to be seen through it. Pull it down by taking hold of the suspensory ligament of the liver, which is still attached to it; as it moves, observe that the lungs follow it closely, providing it has not been injured.
18. Tie a piece of glass rod air-tight into the windpipe (to prevent the lungs collapsing when the chest cavity is opened), and examine more closely the external intercostal muscle in some one of the intercostal spaces. Its fibres have a direction from the posterior border of the rib which bounds the intercostal space in front, backwards and ventrally to the anterior border of the next rib; it is absent between the rib cartilages.
19. The internal intercostal muscle, the fibres of which run from each rib backwards and dorsally to the anterior border of the next rib, is uncovered by the external between the rib cartilages; farther back it may be exposed by carefully dissecting away the external intercostal muscle; at the same time the intercostal nerve and vessels will be brought into view running along the posterior border of the rib bounding the space in front.

20. If the internal intercostal muscle be very carefully dissected away, the parietal layer of the *pleura* will be exposed with the pink lung seen through it.
21. Now open the chest and cut away the ribs as directed in VI. 16. On account of the stoppage of the windpipe the lungs cannot collapse. Note again the phrenic nerve, and finally remove together from the chest, the lungs, trachea and heart.
22. Remove the *pleura* near the spinal column on each side, and note that the internal intercostal muscles are wanting there: by careful removal of the dorsal portions of the external intercostal muscles, the "elevators of the ribs" (*levator costarum*) can be brought into view; each is a small muscle arising from the transverse process of a vertebra, and inserted upon the outer surface of the rib belonging to the next vertebra, near its angle. To see these muscles satisfactorily, they must, however, be dissected out from the dorsal side.
23. Examine the trachea: note the horse-shoe shaped cartilages in its walls, all arranged so that its posterior wall possesses no cartilage. Cut it open below the glass rod; observe that the lungs immediately collapse; note the moist, soft mucous membrane lining it.
24. Posteriorly the trachea divides into the two *bronchi*, of which one enters the root of each lung; trace one as far as you can into the lung, cutting away the soft parts. It divides into numerous *bronchial tubes* (the cartilages in whose walls are so arranged as to leave no side without any), which branch until the branches become too fine to dissect out farther.
- Draw the trachea, bronchi, the uninjured lung, and the bronchial tubes on the other side so far as you have dissected them out.
25. Cut with your razor a thin section of the bronchial tube (of the sheep) which has been imbedded for you in paraffin mixture; mount in glycerine and examine with Oc. 4, Obj. A.



You will easily make out in it several layers : inside an epithelial coat composed of elongated cells ; next a dense connective tissue layer, the *cutis* of the mucous membrane ; then a loose connective tissue layer, the submucous coat ; outside this may be seen a denser layer which contains transversely arranged plain muscular fibres ; and then another connective tissue coat in which the cartilages are imbedded.

26. Scrape off a few of the superficial cells from the inside of the bronchial tube which has been preserved in osmic acid. Mount in water and examine with Oc. 2, Obj. D. Observe the elongated (columnar) cells, with a distinct oval nucleus ; and a number of fine processes (*cilia*) on the broader end of each cell.
27. Snip off a bit of fresh mucous membrane from inside the trachea of a terrapin. Mount it in 0.75 per cent. salt solution, and examine its edges with Oc. 2, Obj. D., until you see cilia in movement. While they move fast only a shimmering border will be seen, along which a current is kept up in a definite direction in the neighboring fluid, as indicated by the blood corpuscles, &c., swept along. As the cilia die and their movements become slower individual cilia can be seen, and their movement can be studied more closely.
28. Cut a thin section of the prepared lung which has been imbedded for you. Mount in glycerine and examine with Oc. 2, Obj. A. Note the smaller bronchial tubes, and between them, making up the great bulk of the lung, the thin-walled polygonal cavities or air cells.
29. Observe, with the assistance of the demonstrator, the circulation of the blood in the lung of the frog. Note especially the extremely close capillary network, far closer than that in the web or mesentery.
30. Study with the assistance of the demonstrator the model illustrating the pressure relationships of the lungs and heart in the chest cavity.

A bell-jar has its bottom closed with a sheet of india rubber. In its cavity lie two elastic bags, of which one is smaller than the other, and has a somewhat thicker wall.

From the smaller bag a tube passes out air-tight through a lateral opening in the bell-jar and dips under water. The bag is also filled with water.

The larger bag has connected with it a tube which passes air-tight through a hole in the cork which closes the neck of the bell-jar, and by which the cavity of the bag communicates freely with the external air. Through the cork passes another tube (tube A), open at present, but which can be closed at pleasure.

At present then the air presses directly through the tube A on the outside of both bags ; it also presses directly on the inside of the larger bag, and indirectly through the water on the inside of the smaller bag. These pressures balancing one another, both bags are now collapsed on account of their elasticity.

As air is drawn out of A both bags dilate ; but the larger one being more extensible, dilates more than the smaller. The cause of the dilatation is that now the air is rarefied in the bell jar, and so presses less on the outsides of the bags ; consequently, the internal pressure is no longer balanced and dilates the bags, air entering the larger and water the smaller. If the tube A be now closed both bags remain dilated.

If now the india-rubber bottom of the bell-jar be pulled down so as to enlarge its cavity, the air in it will be still more rarefied and its pressure diminished, and both bags will again dilate, air entering one and water the other ; but, as before, the more extensible bag dilates most. This represents an inspiration. If the india-rubber be let go it returns to its former place and both bags contract, driving out some of their contents ; this represents an expiration.

In the chest at rest the state of things in fact answers to that in the bell-jar when the tube A was first closed, the lungs answering to the more extensible bag, the heart to the less extensible, and the heart and lungs being in that state of extension at which equilibrium is produced between the pressure of the air or blood in their cavities on the one hand, and the elasticity of their walls and the pressure outside them on the other; but in the chest this outside pressure is not exerted, as in the model, by remaining air, but by the walls of the chest and the other organs with which the heart and lungs are in contact. When the walls of the chest move so as to enlarge the thoracic cavity, their pressure is removed or diminished, and then lungs and heart are dilated by the pressure of the air and blood in their cavities: but the lungs being far more extensible than the heart, dilate much more; as they dilate, the air inside them is rarefied, and external air rushes in through the trachea until equilibrium of pressure is produced between the external air and that in the lungs, and so an inspiration is brought about: in expiration exactly the reverse phenomena take place.

31. Examine fresh-drawn venous and arterial blood: observe the dark purple red color of the former, and the bright scarlet red color of the latter. Whip both specimens and set them aside: notice that as the venous blood is whipped in contact with the air it becomes brighter; but if left at rest for a time both specimens become somewhat venous.
32. Pass a stream of carbonic anhydride through some whipped blood which has been rendered arterial by shaking with air. The bubbling of the carbonic anhydride through the blood will (like the shaking) bring new portions of it constantly in contact with the air, and the blood, though perhaps somewhat changed, will still remain arterial in character.

33. Add a small quantity of a reducing substance (Stokes' solution) to arterialized blood, and mix with a gentle shake. Observe that the blood very rapidly becomes venous in character; much more rapidly than when it was let stand without any addition. Shake the mixture up briskly with air, it again is arterialized; let it stand at rest for a brief time, it again becomes venous.

34. Observe that all the above results can be obtained when oxygen is substituted for air.

From the above we may conclude that contact with oxygen converts venous blood into arterial: that contact with carbonic anhydride will not convert arterial blood into venous: that reducing agents will convert arterial blood into venous: that blood removed from the body develops reducing substances. The change of venous blood in the lung capillaries into arterial depends then on the access of oxygen; the change from arterial to venous, in the systemic capillaries, upon the access of reducing matters.

35. Observe, with the assistance of the demonstrator, that whipped arterialized blood exposed in an air-pump to a gradually increased vacuum at first gives off comparatively little gas, as indicated by the bubbles arising from it, but that finally as the vacuum approaches perfection it froths up and gives off a large quantity. Notice that blood-serum under these circumstances gives off much less gas. We may conclude, therefore, that a large portion of the gas which can be obtained from the blood by exposure to a vacuum is held by the red corpuscles.

36. Examine with your microscope crystals of the coloring matter (hæmoglobin) of the red corpuscles.

37. Examine a watery solution of hæmoglobin which has been exposed to the air; it is red, but not of so bright a tint as arterial blood; this depends on the fact that hæmoglobin in solution

reflects less light than when contained in the solid corpuscles. Shake up some of your reducing solution; it assumes a darker color: shake it up again briskly with air; it again becomes bright in color. We may assume then that the color of arterial blood depends on the fact that the hæmoglobin of its red corpuscles is combined with oxygen (forming oxyhæmoglobin), while the color of venous blood depends on the fact that more or less of the hæmoglobin of the red corpuscles has been deprived of its oxygen.

38. [Examine, with the assistance of the demonstrator, solution of oxyhæmoglobin with the spectroscope or micro-spectroscope. First notice the complete or continuous spectrum when nothing is interposed between the source of light and the instrument. Next introduce between the light and the lens of the instrument a solution of oxyhæmoglobin: when this has a certain concentration you will see all the original spectrum except a portion of the blue end, and two bands near one another about the green area of the spectrum, which are dark and so make the series of colors discontinuous. The oxyhæmoglobin therefore blocks or cuts off the rays of light which formerly reached this part of the spectrum.]
39. [Examine similarly solution of reduced hæmoglobin. Instead of the two dark bands now is seen one rather broader and with less defined margins, in a position about between that of the oxyhæmoglobin bands.]
40. [Examine similarly the spectrum of the solution obtained by diluting venous blood with water. It gives the spectrum of oxyhæmoglobin, so that ordinary venous blood still contains a considerable quantity of that substance; enough in fact for its two well defined absorption bands to conceal the presence of the less marked absorption band of the reduced hæmoglobin, which lies on and near them.]

41. [Examine similarly the absorption spectrum of the blood of an asphyxiated animal: notice that it gives the absorption bands of reduced hæmoglobin. Under ordinary circumstances, therefore, by no means all of the oxygen is removed from the oxyhæmoglobin as the blood flows through the systemic capillaries, but in death from suffocation all this oxygen is used up.]
42. Draw air for a short time through some lime water: no noticeable turbidity will be produced. Now blow air from your lungs through the lime water for an equal time; the lime water will become distinctly turbid from a precipitate of calcic carbonate. The air of the room then contains comparatively little carbonic anhydride; but that expired from the lungs contains a considerable quantity.
43. Observe that a breathing animal gives off a considerable quantity of carbonic anhydride and aqueous vapor from its lungs.

Notice the arrangement of the apparatus: at one end is a water aspirator which draws air through the whole; at the opposite is a tube through which the air enters, and from which it bubbles through bulbs containing solution of caustic potash which takes all carbonic anhydride out of it; it then passes over bits of pumice stone wet with sulphuric acid, which takes all water vapor out of it; next it goes through the bell-jar, connected air-tight with the trachea of the chloral-ized rabbit, so that the animal breathes out of and into this jar. The air from the bell-jar passes into a bulb surrounded by ice, and then through bulbs containing baryta water, and so to the aspirator.

When the apparatus has been at work some time, notice that a considerable quantity of water has been condensed in the cooled bulb, and that the baryta water has become turbid from the precipitation of barytic carbonate. The animal then breathing-in air containing neither water vapor nor carbonic

anhydride, has imparted a considerable quantity of both these substances to the air it expires.

44. Observe, with the assistance of the demonstrator, the chloralized rabbit whose chest has been opened while artificial respiration is kept up. Notice that the blood on the right side of the heart, as seen through the thin-walled auricular appendage, is venous; while on the left side, as seen in the same way, it is arterial.

When the artificial respiration is carried on very vigorously, observe that the blood on both sides of the heart becomes arterial in color. If the artificial respiration be now stopped, observe that for a short time the animal makes no respiratory movements, as seen on either nostrils, ribs or diaphragm. The blood now contains so much oxygen that it does not stimulate the respiratory centre from which the impulses proceed along the various nerve-paths to excite contraction of the respiratory muscles.

After a time, however, the oxygen in the blood getting partly used up, the respiratory centre is again excited, and the animal makes respiratory movements, though of course, its thorax being open, these bring no air into its lungs. Soon, the artificial respiration being still discontinued, the respiratory movements become more and more violent, and at last general convulsions supervene. Meanwhile the blood on the left side of the heart becomes more and more venous; the heart's beats become feebler and finally irregular, and the right side of the organ becomes gorged with blood. If the artificial respiration be now resumed, before the heart has quite stopped beating, things come back gradually to their original condition.

45. When the *phrenic nerves* are divided and the artificial respiration stopped until the animal becomes dyspnoëic, observe that the diaphragm no longer contracts when the ribs ascend; it may be pulled up and down a little by the movements of the ribs, but its own muscular fibres do not contract.

When either phrenic nerve is stimulated, observe that the diaphragm contracts on that side; when both are stimulated the diaphragm contracts on both sides, becomes flatter towards the chest, and pushes down the abdominal viscera: when the stimulation is discontinued, observe that the latter push the diaphragm up again. The diaphragm by its contractions, therefore, enlarges the chest cavity, and its motor nerves are the two phrenics.

## VIII.

### ALIMENTARY CANAL AND DIGESTION.

1. Lay the dead rat on its back, and fix it, if necessary, by driving tacks through the paws. Remove the skin from the ventral surface and sides of neck, chest and abdomen.
2. Note in the neck region the large *salivary glands* which meet in the middle line: the posterior gland, close to the middle line, rounded and compact, is the *submaxillary*: on raising it, its *duct* will be seen passing forwards to the mouth, into which it may be followed by separating the halves of the lower jaw.
3. The large gland, composed of several loosely united lobes, and reaching from the neighborhood of the ear to the submaxillary, is the *parotid*. Its duct will be found passing forwards over the face to the mouth, near the angle of which it passes in through the cheek muscles.
4. In front of the submaxillary will be found a small gland, the *sublingual*.
5. Remove the muscles, &c., covering the larynx and trachea: cut away the front and side walls of the chest and abdomen: remove larynx, trachea, lungs and heart.

6. The *gullet*, a slender muscular tube, will now be exposed in the neck; trace it through the chest: make a diagram of the abdominal viscera as now exposed before displacing any of them; then turning the liver up out of the way, follow the gullet in the abdomen until it ends in the stomach.
7. Note the form of the latter organ: its projection (*fundus*) to the left of the entry of the gullet: its *great* and *small curvatures*: its narrower *pyloric portion* on the right, from which the small intestine proceeds. Attached to the stomach, and hanging down over the other abdominal viscera, notice a thin membrane, the *omentum*.
8. Follow on and unravel the coils of the small intestine, spreading out as far as possible the delicate membrane (*mesentery*) which slings it. In the mesentery are numerous bands of fat, running in which will be seen blood-vessels and lacteals.
9. The small intestine ends by opening into the side of the large. Observe the *cæcum* or blind end of the latter, projecting on one side of the point of entry of the small intestine; on the other side follow the large intestine until it ends at the anal aperture, cutting away the front of the pelvis to follow its terminal portion (*rectum*). The portion between the cæcum and the rectum is the *colon*.
10. Spread out the portion of the mesentery lying in the concavity of the first coil (*duodenum*) of the small intestine: lying in this portion of mesentery will be seen a thin branched glandular mass, the *pancreas*.
11. Observe the *portal vein* entering the under side of the liver by several branches. Alongside it will be seen the *gall duct*, formed by the union of two main branches, and proceeding, as a slender tube, through the pancreas, to open into the duodenum about an inch and a half from the pyloric orifice of the stomach.
12. Note the *spleen*: an elongated red body lying in the mesentery behind and to the left of the stomach.

13. Divide the gullet at the top of the neck, and the rectum close to the anus, and dividing mesenteric bands, &c., by which intermediate portions of the alimentary canal are fixed, remove the whole tube ; then cutting away the mesentery, spread it out at full length, and note the relative length and diameter of its various parts. The whole is seven or eight times as long as the head and trunk of the animal, and the small intestine forms by far the greater part of it.

Make a diagram of the whole.

14. Open the stomach : note that the *mucous membrane* lining the fundus is thin and smooth, and is sharply marked off from the thick corrugated mucous membrane lining the rest of the organ. Pass probes through the *cardiac orifice* into the gullet and through the *pyloric orifice* into the duodenum.
15. Cut out a small portion of the preserved small intestine of the dog, carefully open it in a little water in a watch-glass, and examine its inner surface : observe the closely set projections (*villi*) of the mucous membrane.
16. Open the large intestine opposite the point of entry of the small, and examine the *ileo-colic valve* formed by folds of the mucous membrane. Cut out a small bit of the preserved large intestine and examine as above ; there are no villi, but the mucous membrane presents numerous folds.
17. Remove the liver : note its general form ; convex towards the chest and concave or flattened posteriorly ; its lobes ; its dorsal border rather thicker than the ventral.
18. Cut sections from the stomach which has been imbedded for you ; mount in glycerine and examine with a low power. Note in it four distinct layers : externally a thin connective tissue *peritoneal coat* ; then a much thicker *muscular coat* arranged in two or more layers : inside this a loose connective tissue submucous coat containing numerous blood-vessels : inside, the folded *mucous membrane* almost entirely composed of closely set tubular glands. Draw your section.

19. Prepare and examine similarly sections of small intestine. The same four coats will be seen, but the mucous membrane is raised up into numerous villi, between the bases of which lie the mouths of the glands. Draw.
20. Examine prepared specimens of small intestine in which the lacteals and blood-vessels have been injected with different colors.
21. Prepare and examine sections of large intestine: the villi are absent.  
Put on your objective D and examine the *epithelial cells* lining the glands and the membrane between their orifices: they are elongated (*columnar*) and nucleated, and arranged in a single layer. Draw.
22. Scrape gently the surface of the piece of liver which has been preserved in bichromate of potash. Mount your scrapings in a little water and examine with Oc. 2, Obj. D. Note the polyhedral granular nucleated hepatic cells. They are not flat like the blood corpuscles, for as they float about no edge is exposed. Draw.
23. Cut and mount in glycerine sections of the imbedded liver; examine with Oc. 2, Obj. A. Note that the hepatic cells are collected into masses or *lobules*, separated more or less distinctly from neighboring lobules by connective tissue and vessels. In each lobule the cells have an imperfect radial arrangement. Draw.
24. Examine the prepared specimens of injected liver. Note the *interlobular vessels*; the capillary *lobular plexus*, the vessels of which converge to a vessel, the *intralobular vein*, in the centre: also the hepatic cells indistinctly seen lying in the meshes of the lobular plexus.
25. Observe that solution of grape-sugar warmed with Fehling's solution (cupric oxide dissolved in excess of caustic potash in the presence of a tartrate) causes a reddish or yellow precipitate of cuprous oxide or its hydrate.

26. Observe that fresh starch emulsion, warmed with Fehling's solution, gives no precipitate, nor does filtered saliva.
27. Add a little saliva to some of the starch emulsion and place in the warm chamber for a few minutes: now test with the Fehling's solution: an abundant precipitate of cuprous oxide will be formed.
28. Observe that solution of any *proteid*, as egg albumen or serum albumen, boiled with Millon's reagent, gives a pink precipitate. Also, that boiled with excess of strong nitric acid it forms a yellow solution, which becomes orange on the addition of ammonia (*xantho-proteic reaction*).
29. Observe that these proteids do not dialyse: after two or three hours the distilled water outside the dialyser (which contains the proteid solution) gives no trace of either of the above (28) reactions.
30. Examine the prepared peptone: a whitish amorphous substance readily soluble in water. Note that its solution gives the above (28) proteid reactions. Observe that it dialyses readily: when some of its solution is placed in a dialyser, the distilled water outside, after an hour or two, gives distinctly those proteid reactions.
31. Examine the artificial gastric digestions which are going on in the warm chamber.
32. Shake up some olive oil with some fresh ox bile: observe that the oil is broken up into a creamy emulsion and remains so for some time.
33. Observe that olive oil will pass through a paper filter moistened with bile better than through one moistened with water; also that oil rises much higher in a capillary tube moistened with bile, than in one moistened with water.
34. Shake up olive oil with infusion of pancreas: observe that this emulsifies it even better than the bile.

35. Treat starch emulsion with pancreatic infusion, and test for grape-sugar: observe that the pancreatic infusion transforms the starch as well as or better than the saliva.
36. Observe the digestion of proteids with pancreatic extract, which is going on in the warm chamber.
37. Observe in the animal which has been killed during digestion the *lacteals* in the mesentery and on the intestines filled with milk-white chyle; and the *peristaltic movements* of the intestines.
38. Take a little of the chyle from an opened lacteal, and examine with your microscope, Oc. 4, Obj. D.

## IX.

### MUSCLE AND NERVE.

1. Remove the skin from a hind limb of the dead frog provided for you. For the most part it will pull off easily, but about the hip and knee-joints you will meet with tough bands fixing it: carefully divide these without injuring the muscles beneath.
2. Of the muscles now exposed select that of the calf of the leg (*gastrocnemius muscle*) for closer examination: note its *belly* and *tendons*: dissect out carefully its *origin* and *insertion*. Draw.
3. Divide its lower tendon (*tendo Achillis*) and turn the muscle up gently towards the knee, so as to expose its deeper surface. Observe the nerve entering this, and trace it back to its origin from a larger trunk behind the knee.
4. Cut out, in the manner shown by the demonstrator, the *urostyle* of the frog and the tissues immediately around it. The abdominal cavity will thus be opened, and in it will easily be found the *sciatic plexus* on each side of the middle line.

5. Follow down the plexus on one side: the nerves forming it will be found ultimately to give rise to a single trunk, the *sciatic nerve*: follow this nerve down the thigh, pushing aside muscles, &c., which come in the way. Note the various branches given off by the nerve in its course.
6. Just above the knee the sciatic nerve divides into two main trunks: follow these down the leg, noting their branches: from one of them arises the branch which supplies the gastrocnemius muscle.
7. Tear apart with your needles a small bit of one of the muscles: mount in water and examine with Oc. 2, Obj. D. Note the *fibres* of which the muscle is composed, and the alternating light and dark stripes across them. Look for fibres showing the *sarcolemma*. Draw.
- [8. Examine with your low power the specimen prepared to show muscular fibres isolated in their whole length: note their elongated form, and the way they taper towards each end.]
9. Tear apart with your needles, in 0.5% common salt solution, a fragment of fresh nerve. Examine with Oc. 2, Obj. D. Note the nerve fibres mixed with connective tissue: observe the double contour of the former. Draw.
10. Examine the specimens which have been prepared to show the *axis cylinder* of the nerve fibres.
- [11. Examine the specimen which has been prepared to show the connection of the nerve fibre with the muscular fibre.]
12. Dissect out very carefully, in a recently killed frog, the sciatic nerve on one side: it is essential that you do not drag or squeeze the nerve.
13. Pinch the top end of the nerve with your forceps: observe that the muscles connected with it contract.
14. Cut off the part of the nerve that you have pinched, and lay a drop of strong salt solution on the cut end of the remainder: the muscles will again be thrown into contraction.

15. Stimulate the nerve, below where the salt solution has injured it, with induced electrical currents in the manner shown by the demonstrator: the muscles will again contract.
16. Tie a bit of thread tightly around the nerve low down in the thigh: none of the above *stimuli* applied above the ligature will now cause the muscles of the leg to contract: applied below the ligature they are still efficacious.
17. Observe, with the assistance of the demonstrator, that when the nerve of the gastrocnemius is stimulated the muscle will lift a considerable weight by its contraction.
18. Obtain and analyse, with the assistance of the demonstrator, the *curve of a simple muscular contraction*.
19. Tear apart a bit of *plain muscular tissue* from the wall of the intestine: note the elongated, nucleated unstriped cells of which it is made up. Draw.

## X.

## THE ANATOMY OF THE CEREBRO-SPINAL CENTRE.

1. Taking the rat provided, remove the skin from its back and skull, and dissect away the muscles from about the arches of the vertebræ and the occipital region.
2. Insert carefully the point of one blade of your large scissors through the thin roof of the cranium, and raise up and remove a bit of the bone. Working from the opening thus made, cut away piecemeal the roof and upper portion of the sides of the skull, taking care, of course, not to insert the scissors into the brain. Then remove similarly the roof of the spinal canal for its whole extent.
3. Separate the muscles at the back of the hip-joint and find the sciatic plexus; trace its constituent nerves forward until they enter the neural canal.

4. Gently pushing the spinal cord to one side, note the origin of the nerves from it; notice the ganglion on each posterior root; the direction and relative length of the roots in different regions; the *cauda equina*; trace up the roots of the sciatic plexus until they join the spinal cord.
5. Remove the membranes from the parts of the cerebro-spinal centre now exposed: noting the *olfactory lobes*, the *cerebral hemispheres*, the *corpora quadrigemina*, the *cerebellum*, *medulla oblongata*, the *cervical* and *lumbar enlargements* of the cord. Trace the latter as the *filum terminale* down to its ending in the tail.
6. Divide the spinal cord opposite the third vertebra. Remove carefully the bony ingrowth from the skull between the cerebrum and cerebellum, and cut away the bone from around the *flocculi* of the latter; then raise the olfactory lobes from the pits in which they lie, and gradually remove the brain from the base of the skull, turning it backwards. As this is done, various nerves passing through foramina in the base of the skull will come into view. Keep a sharp look-out for them, as some are very small; and as each comes into view, divide it so as to leave as much as possible attached to the brain. Having in this way removed the brain and the bit of spinal cord attached to it, place them in a dish containing dilute alcohol.
7. Next remove the spinal cord in the same way, cutting the nerve roots beyond their point of junction; and place it aside in alcohol to harden for future examination.
8. Draw the brain as seen from the dorsal aspect; note olfactory lobes, cerebral hemispheres, corpora quadrigemina, the cerebellum and its flocculi, the medulla oblongata; the smoothness of the cerebrum, and the folded surface of the cerebellum. Raise the cerebellum and, removing the thin membrane which covers it, note the *fourth ventricle* on the dorsal side of the medulla. Push the cerebral hemispheres apart on each side of the median fissure, and notice the *corpus callosum*.

9. Turn the brain over, and carefully remove the *pia mater*, &c., under dilute alcohol, without injuring the various nerves. From before back note—
  - a. The olfactory lobes.
  - b. The cerebral hemispheres, with a white streak on their under surface continuous in front with the olfactory lobes.
  - c. The *optic commissure*, lying in the space left by the posterior divergence of the cerebral hemispheres.
  - d. The *optic nerves* proceeding from it in front and the *optic tracts* behind.
  - e. Immediately between the optic commissure you may find a remnant of the *infundibulum* and *pituitary body*, and behind that the *mammillary body*.
  - f. Behind these organs is the *pons Varolii*, and passing forwards and outwards from it to the cerebral hemispheres are—
  - g. The *crura cerebri*.
  - h. The pons behind passes without any very marked line of division into the *medulla oblongata*.
10. Look for the cranial nerves carefully: according to the care with which you have removed the brain and dissected away the *pia mater* from its base you will find more or fewer of the following:—
  - a. The *olfactory nerves*: proceeding from the ventral side of the olfactory lobes.
  - b. The *optic nerves*, proceeding from the optic commissure.
  - c. The *oculo-motors* (third pair), proceeding from the *crura cerebri*.
  - d. The fourth pair (*pathetici*) appearing round the outer sides of the *crura cerebri*.
  - e. The large fifth pair (*trigeminales*) on the sides of the pons Varolii.
  - f. The sixth pair (*abducentes*) arising on the ventral surface of the medulla where it meets the pons.
  - g. The seventh pair (*facials*) arise from the side of the medulla close to its anterior end.

- h. The eighth pair (*auditories*) arise close behind the seventh, than which they are considerably larger.
  - i. The ninth (*glossopharyngeals*) and tenth (*pneumogastrics*) pairs arise by several roots from the side of the medulla farther back.
  - j. The eleventh pair (*spinal accessories*) arise from the upper part of the spinal cord between the spinal nerve roots, and run forwards to the point of origin of the pneumogastrics, and then turn outwards.
  - k. The twelfth pair (*hypoglossals*) arise by several roots from the medulla, nearer the middle ventral line than the glossopharyngeals and pneumogastrics.
11. Make a careful drawing of the base of the brain with its nerves, as seen in your dissection.
  12. Examine the prepared cat's brain: make out on it the cranial nerves which you failed to see on your own specimen. Notice the greater proportionate size of its cerebral hemispheres; and the convolutions on their surfaces.
  13. Arrange with your neighbor that one brain be divided carefully in the median vertical line from before back: while the other is kept for dissection another way.
  14. In the surface exposed by the section notice the relation of the cerebral hemisphere to the corpora quadrigemina and the cerebellum, and the relative size of these parts. The narrow third ventricle just above the space bounded, on the base of the brain, by the optic commissure in front and the *crura cerebri* behind: and the passage from it to the fourth: the optic thalamus forming the side of the third ventricle: the *corpus callosum* and the plane in which it lies: the choroid plexus passing in between *corpora quadrigemina* and cerebral hemispheres: the *arbor vitæ* in the cerebellum. The *septum lucidum* with the fifth ventricle will probably have been torn away in making the section. Draw your section.

15. Make transverse sections of a cerebral hemisphere at various points : note the external grey layer ; the lateral ventricle ; the grey masses beneath the floor of the latter. Draw : indicating white and grey portions by different shading.
16. In the other brain carefully remove the substance of the cerebral hemispheres and corpus callosum from above until the lateral ventricles are exposed in all their extent : note the grey projections in the floor of each : an anterior (*corpus striatum*) and a much larger posterior (*optic thalamus*). Draw.
17. Expose the *corpora quadrigemina* from above and draw them.
18. Place the spinal cord in a dish containing water or dilute alcohol. Spread out its roots and observe their attachment to the cord more carefully than was possible before removal : note the ganglion of the posterior root. Observe that most of the roots arise by several bundles from the cord.
19. Notice the form of the cord and of its cross section : the *cervical* and *lumbar enlargements* : the *filum terminale*. Draw carefully.
20. Cut the cord across and observe the arrangements of the grey and white portions.

## XI.

### HISTOLOGICAL STRUCTURE OF NERVE CENTRES.

#### REFLEX ACTIONS.

1. Examine with Oc. 2, Obj. A, the prepared stained transverse sections of spinal cord. Note the anterior and posterior fissures ; the *pia mater* and the processes from it which run into the cord, one entirely filling up the posterior fissure ; the more stained grey and the less stained white substance ; the central canal ; the nerve cells in the grey matter. Draw carefully.

2. Put on your Obj. D and examine the cells more closely : observe their nuclei and branches. Draw several carefully. Observe the axis cylinders, seen as red dots in the centre of the cross sections of the medullated nerve fibres of the white substance.
3. Examine the specimens prepared to show isolated nerve cells from the spinal cord of the ox : note the nuclei and nucleoli of the cells ; the granular cell body ; the numerous branched processes : some of the cells show also one long unbranched process.
4. Cut sections of the spinal ganglia which have been imbedded for you : mount in glycerine and examine with your low power : note the connective tissue and the nerve fibres in the ganglion ; and their arrangement : the numerous ganglion cells, with conspicuous nuclei and nucleoli. Draw.
5. Tease out in glycerine a bit of a sympathetic ganglion : study and draw the ganglion cells.
6. Examine and sketch the prepared stained sections of cerebrum : note the numerous nerve cells in the grey matter.
7. Examine the prepared sections of cerebellum : observe and draw the pear-shaped nerve cells with their processes, seen in the deeper layer of the grey matter.
8. Learn, with the assistance of the demonstrator, how to destroy a frog's brain : this operation leaves the animal devoid of consciousness and of the power of spontaneous movement. Once it has recovered from the shock of the operation and drawn its hind limbs up into their natural position, observe that the animal makes no further attempt at movement except in response to external changes ; and that its movements then are not only often different in themselves from those executed under similar conditions by a frog with its brain, but differ also in the fact that they are invariable and can be predicted.



9. Gently stroke one flank with the point of a needle: a twitching of the muscles immediately under the point irritated will follow.
10. On increasing the stimulus the consequent contractions will spread to other muscles on the same side, and finally to muscles on the other side of the body; and movements of the limbs tending to push the point away will occur.
11. Hang up the frog by its lower jaw, so that the rest of its body is not in contact with any support. Observe the results —
  - a.* Of pinching one toe gently.
  - b.* Of pinching the skin about the anus.
  - c.* Of pinching the skin on the back.
  - d.* Of prolonged pinching in spite of efforts to pull the toe away or to push the forceps away.
12. Instead of pinching, let one toe dip into very dilute sulphuric acid (just strong enough to be tasted): as soon as the toe is pulled out, immerse the leg in a beaker of clean water to wash away the acid.
13. Lay bits of paper, moistened with acetic acid, on various parts of the frog's skin: observe that the movements excited in most cases are such as tend to remove the irritant: wash carefully after each experiment.
14. Having found a place from which the acidulated paper is wiped off always by one leg, tie a weight to that limb so that it cannot be used; then put on the stimulant: observe that after vain attempts to use the usual leg, the other is employed to wipe the paper away.
15. Observe the brainless frog which has been poisoned with strychnia: powerful reflex movements are very easily excited in it, but they have lost their co-ordination to an end — their purposive character.
16. Destroy the spinal cord in both the above frogs: it will be no longer possible to excite any reflex movements.

## XII.

## THE LARYNX.

1. Examine the cartilages of the sheep's larynx and draw them from different sides. The *thyroid cartilage*: its form, size, &c.; upper and lower *cornua*; the articular surfaces on the latter. The *cricoid cartilage*: its form, &c.; the articular surfaces on it for the lower cornua of the thyroid and for the arytenoids. The *arytenoid cartilages*: the *cornicula laryngis* (cartilages of Santorini) composed of yellow elastic cartilage, continuous with the upper ends of the arytenoid cartilages.
2. Place the cartilages together in their natural positions, fixing them with pins.
3. Dissect away the various extrinsic muscles, remnants of the gullet, pharynx, &c., attached to the sheep's larynx provided for you. Observe the epiglottis overhanging its upper aperture, which is bounded on the sides and behind by folds of mucous membrane and the *cornicula laryngis*. Looking into the larynx through the opening, observe the projections formed by the *vocal cords*; and the V-shaped passage between them (*glottis*).
4. Clean the membrane between the hyoid bone and the thyroid cartilage: make out the connection between the upper cornua of the cartilage and the great cornua of the hyoid.
5. Clean the crico-thyroid membrane in front where uncovered by the *crico-thyroid muscles*: dissect out these muscles very carefully: clean the rest of the outer surface of the thyroid cartilage, and draw the parts then exposed so as to show the position, form, &c., of the crico-thyroid muscle.
6. Proceeding then to the back of the larynx, remove the mucous membrane covering the posterior surfaces of the cricoid and arytenoid cartilages. Clean carefully the *arytenoid* and *posterior crico-arytenoid* muscles thus exposed. Draw.

7. Fixing the larynx so that it is turned over a little on one side, divide the crico-thyroid muscle on the opposite side, and carefully turn outwards that half of the thyroid cartilage, detaching the tissues adherent to its inner side.
8. Now dissect out the insertion of the posterior crico-arytenoid muscle on the side from which the thyroid cartilage has been raised, and clean the *lateral crico-arytenoid*.
9. Carefully clean the paler *thyro-arytenoid* muscle, which is largely developed in the sheep, its fibres forming a broad sheet passing from the arytenoid cartilage to the re-entering angle of the thyroid cartilage for nearly its whole length.  
 Draw the muscles, &c., now exposed.
10. Observing carefully the origins and insertions of the various muscles, make out what movements they will produce in the cartilages to which they are attached.
11. Carefully divide the cricoid cartilage in the middle dorsal line : turn then the halves outwards and examine the interior of the larynx.
12. Examine specially the boundaries of the glottis : for its posterior half or more it will be seen that the wall of the aperture is bounded by the arytenoid cartilages covered with mucous membrane ; and it is only its anterior portion that has the vocal cords on its sides. Putting the halves of the cricoid cartilage together again, observe the wider opening at the posterior part of the glottis (*glottis respiratoria*) as compared with its anterior narrow portion (*glottis vocalis*) between the vocal cords. Notice how this anterior portion will be more or less opened or shut by rotation of the arytenoid cartilages.
13. Dissect away the muscles, mucous membrane, &c., of the larynx and make out its ligaments and the articulations of its cartilages. Note the attachment of the cartilage of the epiglottis to the upper part of the thyroid cartilage : the movements permitted at the cricoid-thyroid and crico-arytenoid articulations and the

bundles of elastic fibres just beneath the mucous membrane, which form the vocal cords.

14. Examine the prepared cartilages and dissections of the human larynx and compare them with those of the sheep. In the former note especially the *ventricle of the larynx* and the *false vocal cords*.
15. Analyse some of the vowel sounds with the help of Helmholtz's resonators.
16. Study the form of your mouth cavity during the production of the various vowel sounds, and the movements of its walls in producing the different consonants.

### XIII.

#### THE KIDNEYS.

1. Remove the alimentary canal from the abdominal cavity of the dead rat: with your stronger scissors carefully remove the front of the bony pelvic ring. The *kidneys* will easily be recognized, one on each side of the back part of the abdominal cavity, the right farther forward than the left.
2. Dissect away neatly the connective tissue, &c., in front of the vertebral column, so as to clean the *inferior vena cava* and the abdominal aorta. Trace out the *renal arteries* and *veins*.
3. Find the *ureter*, a slender tube passing back from the kidney towards the pelvis: it leaves the inner border of the kidney behind the vein and artery: and lying at first at some distance from the middle line, converges towards its fellow as it passes back.
4. Follow the ureters back until they reach the *urinary bladder*; dissect away the tissues around the latter and note its form, &c.
5. Make a drawing of the renal organs as now exposed.

6. Open the bladder: look for the apertures of entry of the ureters, and pass bristles through them into those tubes. Note the *mucous membrane* lining the bladder.
7. Remove one kidney from the body and divide it from its outer to its inner border: turn the two halves apart, still leaving them connected by the tissues at the inner border, so as to see the cut surfaces.
8. Note at the inner border (*hilus*) the dilatation (*pelvis*) of the ureter: the outer, darker, granular *cortical portion* of the kidney, and the inner, paler, smoother *medullary portion*: the *papilla* formed by the projections of the medullary substance at the hilus, each contained in a subdivision (*calyx*) of the pelvis of the ureter.
9. Examine and draw carefully a similar section of a sheep's kidney in which the above parts will be more easily seen. Note also in it the *pyramids of Malpighi* (one corresponding to each papilla) and the strata of cortical substance extending some way between them.
10. Cut a section of the prepared kidney so as to include both cortical and medullary parts: mount in glycerine and examine with your low power. Note the arrangement of straight and contorted tubules, and the distribution of *glomeruli*. Draw.
11. Cut a thinner section of the medullary part of the hardened kidney: mount in glycerine, examine with your higher power. Note the *tubuli recti*, which, according to the plane of your section, will be cut in different ways; observe their distinct, often cuboidal, nucleated lining epithelium. Draw.
12. Cut and treat similarly a section from the cortical portion. Note the *tubuli contorti*, and their indistinct granular epithelium: they will be found cut in all directions; some across, some longitudinally, some obliquely. Here and there will be found round empty spaces, which are cavities from which *glomeruli* have fallen out: in other places granular balls, representing shrivelled glomeruli, will be seen occupying these cavities. Draw.

13. Cut a thin transverse section of the papilla of the hardened kidney; mount in glycerine; examine with low, then with high power. Note the transverse sections of the large excretory tubules, and among them a certain number of sections of the smaller tubes forming the *loops of Henle*.
14. Examine the prepared specimens of injected kidney with your low power. Note the blood-vessels, sparse in the medullary part, but forming a close capillary network in the cortical: the little tufts of vessels forming the glomeruli: and the afferent and efferent vessels of the glomeruli. Select a good bit of the specimen and draw.
15. Tease apart with your needles in water a bit of the preserved muscular coat of the bladder. Examine with Oc. 2, Obj. D. Note and draw the *contractile fibre-cells*.
16. Cut sections of the preserved and imbedded mucous membrane of the bladder: note its stratified epithelium: the superficial cells flattened, the deeper elongated. Draw.

#### XIV.

##### THE SKIN AND ITS APPENDAGES.

- i. Examine with your low power and draw the prepared sections of skin. Note —
  - a. The *epidermis* (*cuticle*); its superficial *horny layer*, and deeper, less transparent *mucous layer* (*rete mucosum*, *Malpighian layer*). According to the mode of preparation the horny layer may be more or less deeply stained than the *rete mucosum*.
  - b. The *dermis* (*corium*): deeply stained and with numerous projections (*papillæ*) on its surface, which fit into hollows on the deeper side of the epidermis. Note the numerous blood vessels cut across in the dermis.

- c.* The *subcutaneous areolar tissue*, into which the dermis gradually passes on its deeper side. Composed mainly of a loose network of bundles of tissue like that of the dermis, the meshes of the network being filled up with fat cells and the deep ends of sweat glands.
2. Examine with Oc. 2, Obj. D. Picking out the thinnest part of the specimen, note the columnar cells forming the deepest layer of the epidermis: superficial to these, the numerous strata of roundish cells, then strata in which the cells begin to get somewhat flattened parallel to the surface. In the deeper part of the horny layer individual cells can still be recognized; but not in its superficial layers. Draw carefully.
  3. Tease apart with needles in water a small bit of dermis from a fresh piece of skin. Examine, Oc. 2, Obj. D. Note the connective tissue fibres of which it is mainly composed. Treat with dilute acetic acid: note that most of the fibres swell up and disappear; the majority are therefore *white fibrous tissue*. (p. 7, Obs. 13).
  4. Examine and draw specimens prepared to show the sweat glands. Note—
    - a.* The contorted portion of the duct in places where it can be seen passing through the horny layer of the cuticle.
    - b.* The slightly waved or straight part of the duct passing through the dermis, and recognisable by being its epithelium, stained similarly to the *rete mucosum* of the epidermis.
    - c.* The coiled mass formed in the subcutaneous tissue by the secreting part of the tube which will be cut across in various planes: note in the transverse sections the epithelium lining it, and its central lumen.
  5. Pull out one of your eyelashes; wash in dilute potash solution and mount in the same. Examine with your low power. Note the bulbous enlargement or *root* of the hair: its *shaft*, in which more or less of a darker central *medulla* can be seen: and the tapering *point* where the medulla is absent. Draw.

6. Examine with Oc. 2, Obj. D. Bring the upper surface of the shaft into focus : note on it the fine markings caused by the cells of the *hair cuticle*. Draw. Focus deeper and examine the *medulla*, and note the fibrous part (*cortical substance*) lying between cuticle and medulla, and in most hairs containing collections of pigment granules.
7. Examine with your low power the prepared specimens which show the *hair follicles* and the hair roots *in situ*. Note the epidermic and dermic layers in the follicles ; in some places the small dermic papilla at its base, on which the hair sits, can also be seen. Note also the *sebaceous glands* on the sides of the hair follicles : in some places their openings into the latter will be seen. Draw.
8. Picking out a good part of the specimen, put on your Obj. D, and trace out the continuity of the hair with the epidermic lining of the follicle.
9. Examine the prepared stained sections of nail with your low power. Note the deeply colored deeper layer (*rete mucosum*) produced into numerous little clubbed processes (which originally fitted into the hollows between the rows of papillæ on the dermis of the bed of the nail) and the less stained outer horny layer. Draw.
10. Examine with your high power : make out the form, &c., of the cells in the various layers.
11. Examine the prepared specimens showing *tactile corpuscles* in the papillæ of the dermis. Draw.
12. Take the fresh *Pacinian body* provided by the demonstrator : lay in 1 per cent. acetic acid on a slide and examine with the unassisted eye : note its central opacity, then put on a cover, press gently and examine with Oc. 4, Obj. A. Note—
  - a. The numerous concentric nucleated capsules forming most of its mass.
  - b. The way in which the inner capsules are more closely packed.

- c. The central non-laminated "*colloid mass*" or "*core*."
  - d. The nerve fibre, entering at one end and passing on through the capsules into the central mass. Draw.
13. Use Oc. 2, Obj. D, and try and find the swollen termination of the axis cylinder of the nerve fibre.
  14. Cut thin sections from the imbedded bits of *mucous membrane* of the tongue. Mount in glycerine and examine, first with a low, then with a higher power. Compare its *epithelium* and *corium* with the epidermis and corium of the skin.

## XV.

### THE EYE.

1. Place the bullock's eye in water, and remove from around it the loose fat and connective tissue. As this is done, the tendons of the straight and oblique muscles will be seen; do not detach them. Clean carefully also the attachment of the large *retractor of the bulb* muscle all round the equatorial region of the eyeball.
2. Note now carefully the *sclerotic* and *cornea*; the *conjunctiva* covering the anterior part of the sclerotic: the entry of the *optic nerve*: the form of the eyeball as a whole: the curvature of the cornea. Through the cornea examine the *iris* and *pupil*.
3. Remove the eye from the water and carefully cut away the cornea along its junction with the sclerotic. As the first incision is made, note the escape of the *aqueous humor*.
4. Replace the eye in water and fix it with pins to the wax, pupil uppermost. Examine the *iris* more closely: raise the inner edge so as to see the so-called *posterior chamber* of the aqueous humor. Feel the convex anterior surface of the *lens* projecting in the aperture of the pupil.

5. Make an incision in the sclerotic at one point, extending back for about one-quarter of an inch from the attachment of the iris. Raise the edges of this cut, and find in them the *canal of Schlemm* cut across. Follow this canal all round along the outer edge of the iris, cutting it open as you proceed.
6. Make four radial equidistant incisions through the sclerotic from its anterior edge to near the point of entry of the optic nerve. Taking the greatest care not to injure parts beneath the sclerotic, raise the four flaps thus marked out and pin them back. The pigmented *choroid coat* will thus be exposed. Just outside the canal of Schlemm, some fibres will have to be torn through, in order to reflect the sclerotic; they pass from the sclerotic backwards and inwards to the choroid.
7. At the front part of the choroid and just outside the ring formed by the canal of Schlemm, it will be seen to be unpigmented. If a small strip of this unpigmented portion be raised in the forceps, it will be found to tear off readily in a radial direction: it is the radial portion of the *ciliary muscle*, the sclerotic attachment of which has been just torn through.
8. Make radial incisions in the iris and reflect it. The whole front of the lens and, outside its edge, part of the front of the *vitreous humor* enclosed in its *hyaloid membrane*, will be now exposed. On the inner surface of the reflected flaps of iris will be seen the folds of the front part of the choroid, forming the *ciliary processes*.
9. Gently raise the ciliary processes and push them outwards: as this is done, the inner attachment of the folded *suspensory ligament* of the lens will be seen.
10. Now very carefully reflect the whole choroid: as this is done, notice the bright iridescent patch (*tapetum*) on its inner surface.
11. The retina will now be exposed as a pink membrane lying on the hyaloid membrane. Examine its inner surface from the front through the transparent vitreous humor. Observe the place where the optic nerve enters, marked out by the vessels radiating from that point.

12. Remove the lens, examine its form, &c., squeeze it and note the greater density of its inner layers.
13. Cut the hyaloid membrane, and press out and examine the transparent jelly-like vitreous humor.
14. Examine first with low then with high power the prepared sections of retina Draw. Note—

- [*a.* The internal limiting membrane.]
- b.* The nerve fibre layer.
- c.* The nerve cell layer.
- d.* The molecular layer.
- e.* The inner granular layer.
- f.* The intergranular (fenestrated) layer.
- g.* The outer granular layer.
- h.* The external limiting membrane.
- i.* The rod and cone layer.
- j.* The pigmentary layer.
- k.* The radial fibres of Müller.

15. Examine the specimen prepared to show a bird's-eye-view of a retina from the outer side. Notice the cones scattered here and there among the rods.
16. Tease out a bit of fresh frog's retina in a drop of osmic acid solution. Examine with your high power. Observe the gigantic rods and the tendency of their outer segments to split up into discs. Draw.
- [17. Examine the prepared sections of cornea and conjunctiva.]
18. Notice in the freshly extracted eye of an albino rabbit the small inverted image, formed on the back of the eyeball, of objects held in front of the eye.
- 19 Study, with the assistance of the demonstrator, the path of the light rays through the artificial eye, and the necessity for accommodation in order to obtain clear images of objects at different distances.

20. Observe that your own eye is not accommodated for distinct vision at different distances at one time.
21. Perform Scheiner's experiment with the assistance of the demonstrator. Determine your near limit of accommodation.
- [22. Observe the changes of the front surface of the lens during movements of accommodation, by means of Helmholtz's phakoscope.]
23. Determine the position of your "*blind spot*."
24. Study Purkinje's figures.
25. Observe that in vision with two eyes, objects out of the *horopter* are seen double.

## XVI.

## AUDITORY, GUSTATORY AND OLFACTORY ORGANS.

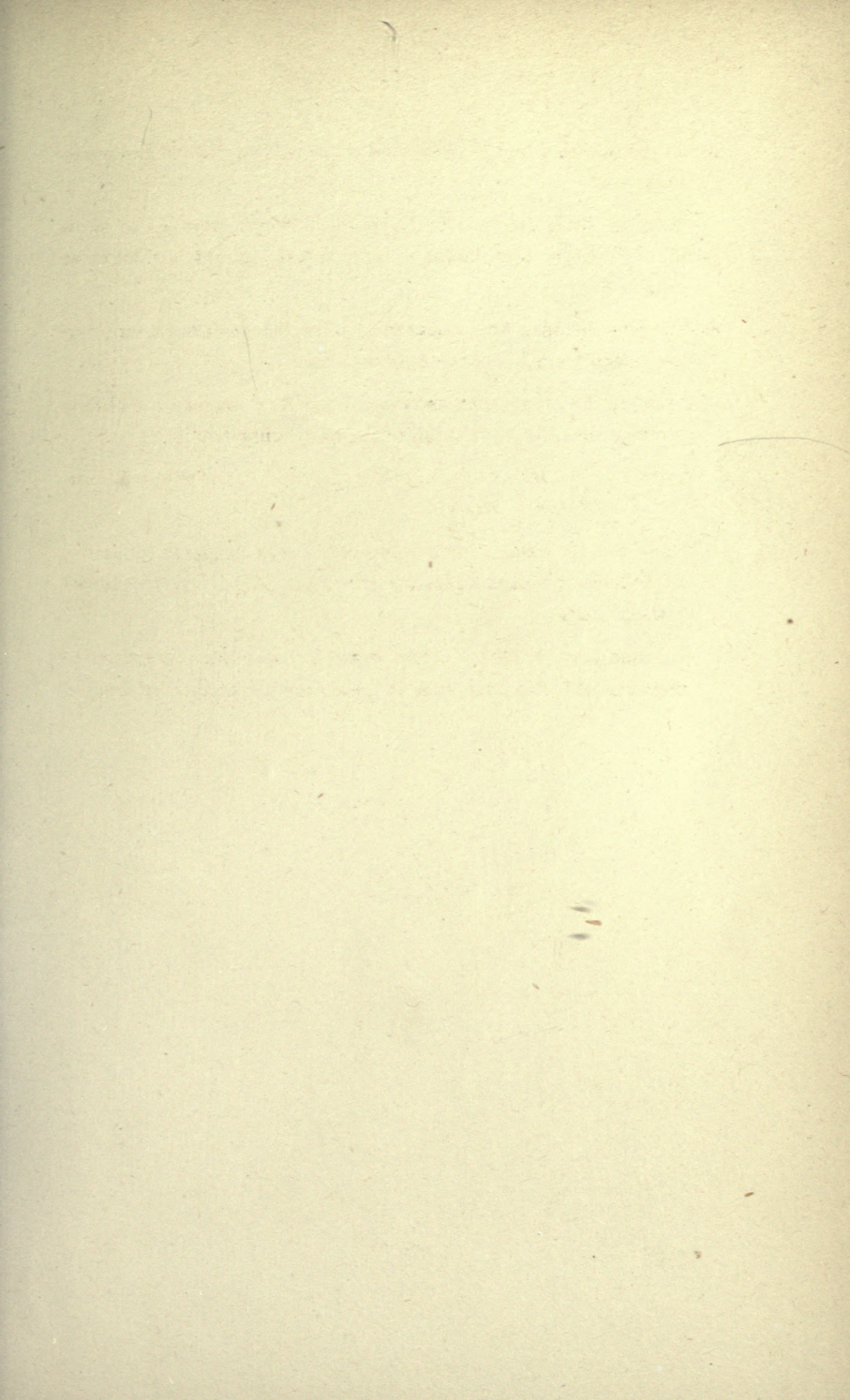
1. Examine and draw the bones of the tympanic cavity.
2. Examine the specimens prepared to show the *tympanic membrane* and *Eustachian tube*, and the tympanic bones *in situ*.
3. Examine and draw the preparation showing the *bony semicircular canals*.
4. Examine and draw the preparation showing the *membranous semicircular canals* and the *vestibule*.
5. Examine with Oc. 2, Obj. A., the prepared sections of *cochlea*.

Draw. Note carefully—

- a. The *modiolus*.
- b. The *lamina spiralis*.
- c. The *basilar membrane*.
- d. The *membrane of Reissner*.
- e. *Scala media*, *scala vestibuli* and *scala tympani*.
- f. The *rods of Corti*.
- g. The *hair cells*.
- h. The *membrana tectoria*.

6. Examine with a higher power the structures on the basilar membrane.
- [7. Examine with Oc. 2, Obj. D., the specimens prepared to show the epithelium and hairs in the *ampullæ* of the semicircular canals.]
8. Examine the specimen prepared to show the *turbinate bones*, and the *cribriform plate* of the ethmoid bone.
9. Examine the preparation showing the yellow mucous membrane covering the olfactory region of the nasal chamber.
10. Examine with Oc. 2, Obj. D., the prepared sections of the *Schneiderian membrane*. Draw.
11. Tease out in water a small portion of the prepared olfactory epithelium; mount and examine with Oc. 2, Obj. D. Draw the two kinds of cells.
12. Examine (Oc. 2, Obj. D.) and draw the specimens prepared to show the so-called *taste-buds* in the epithelium of parts of tongue.













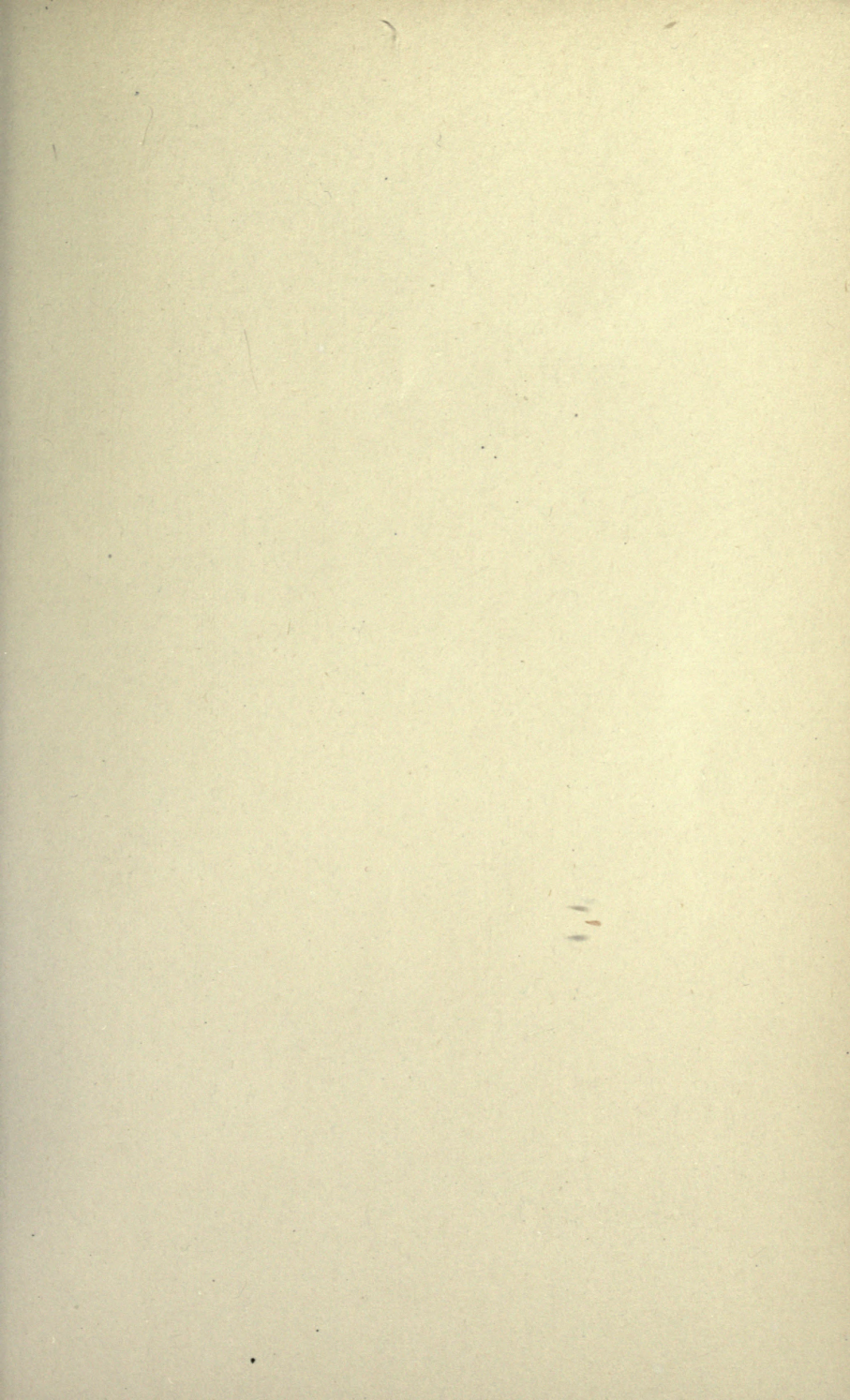












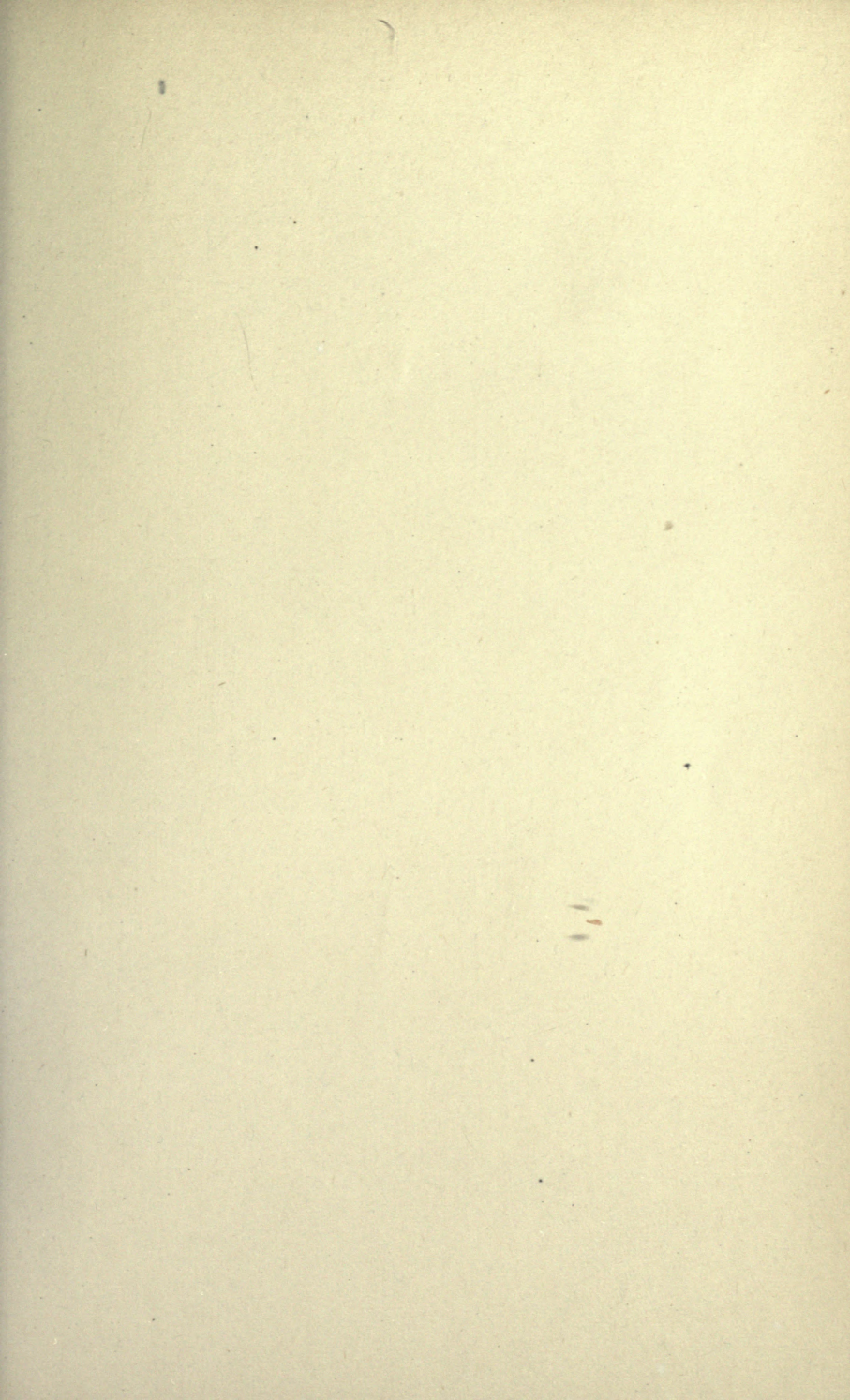




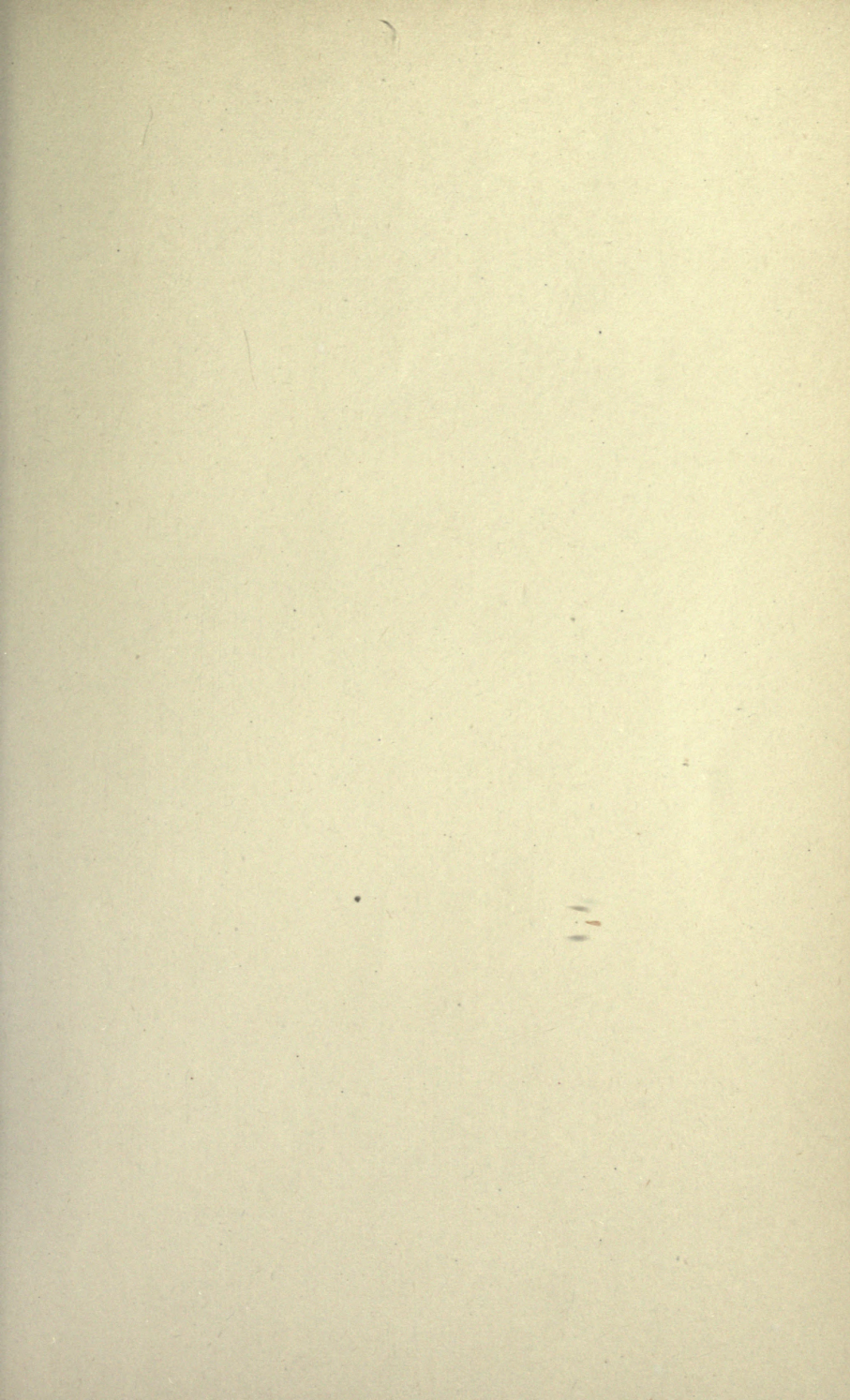








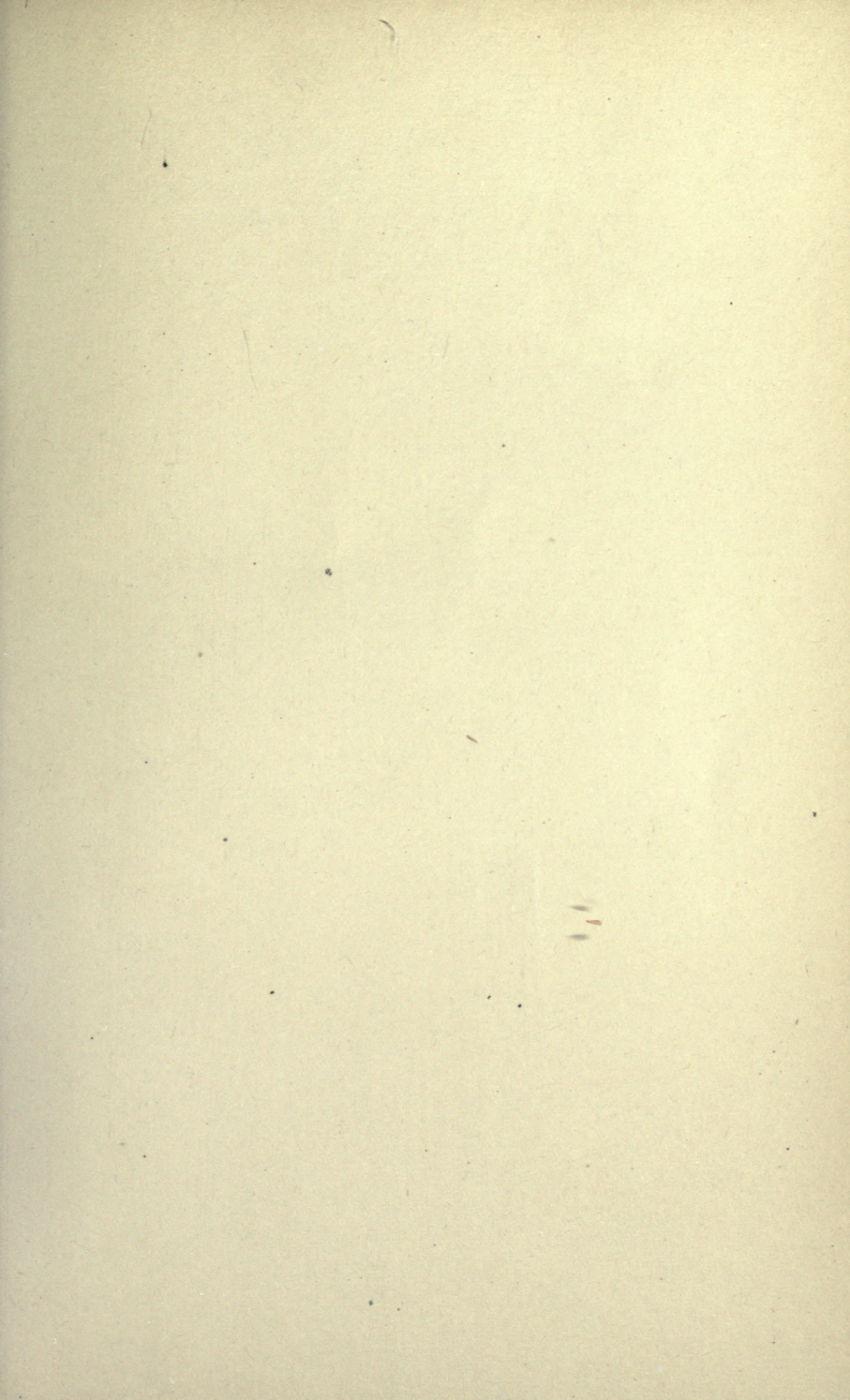




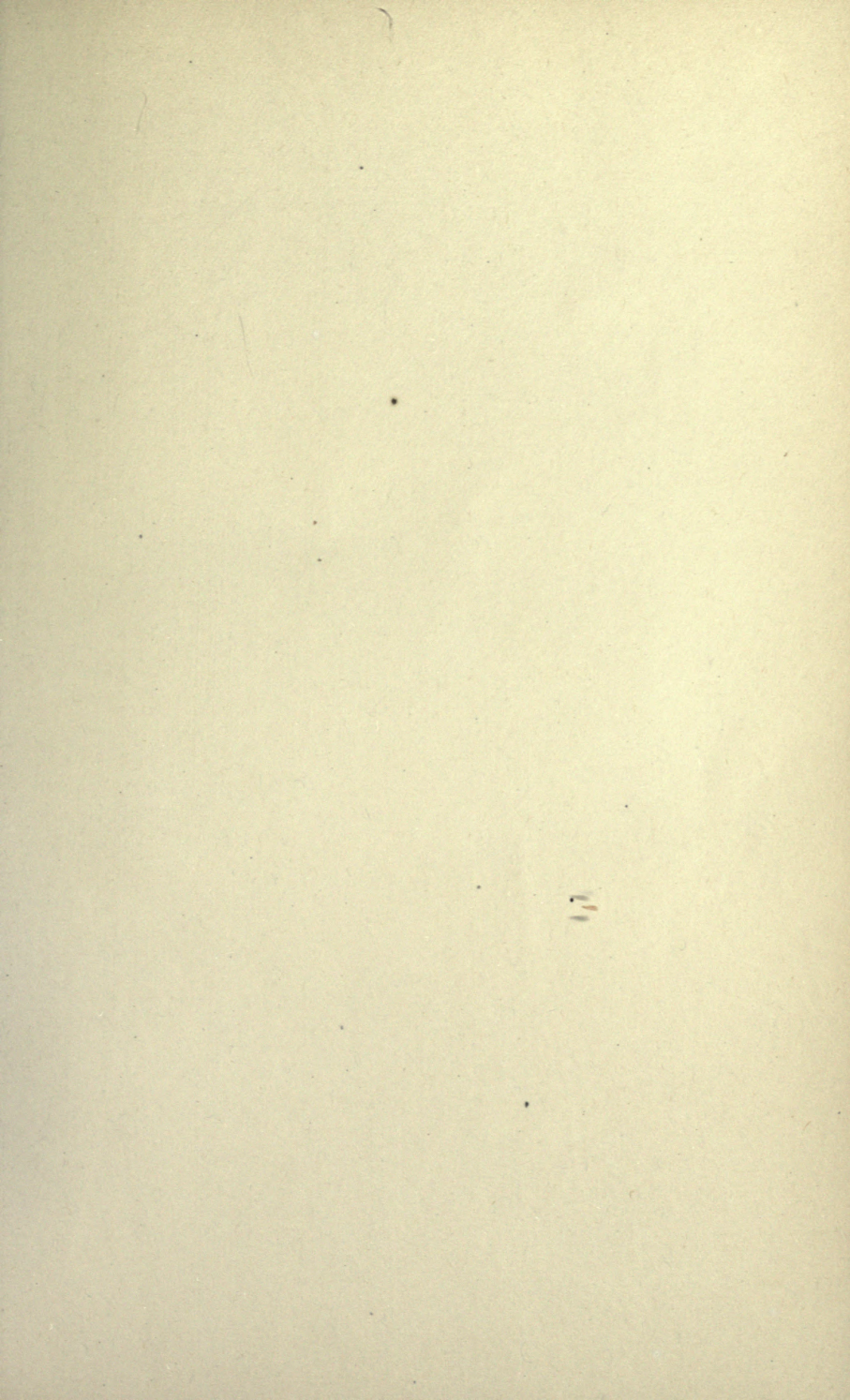




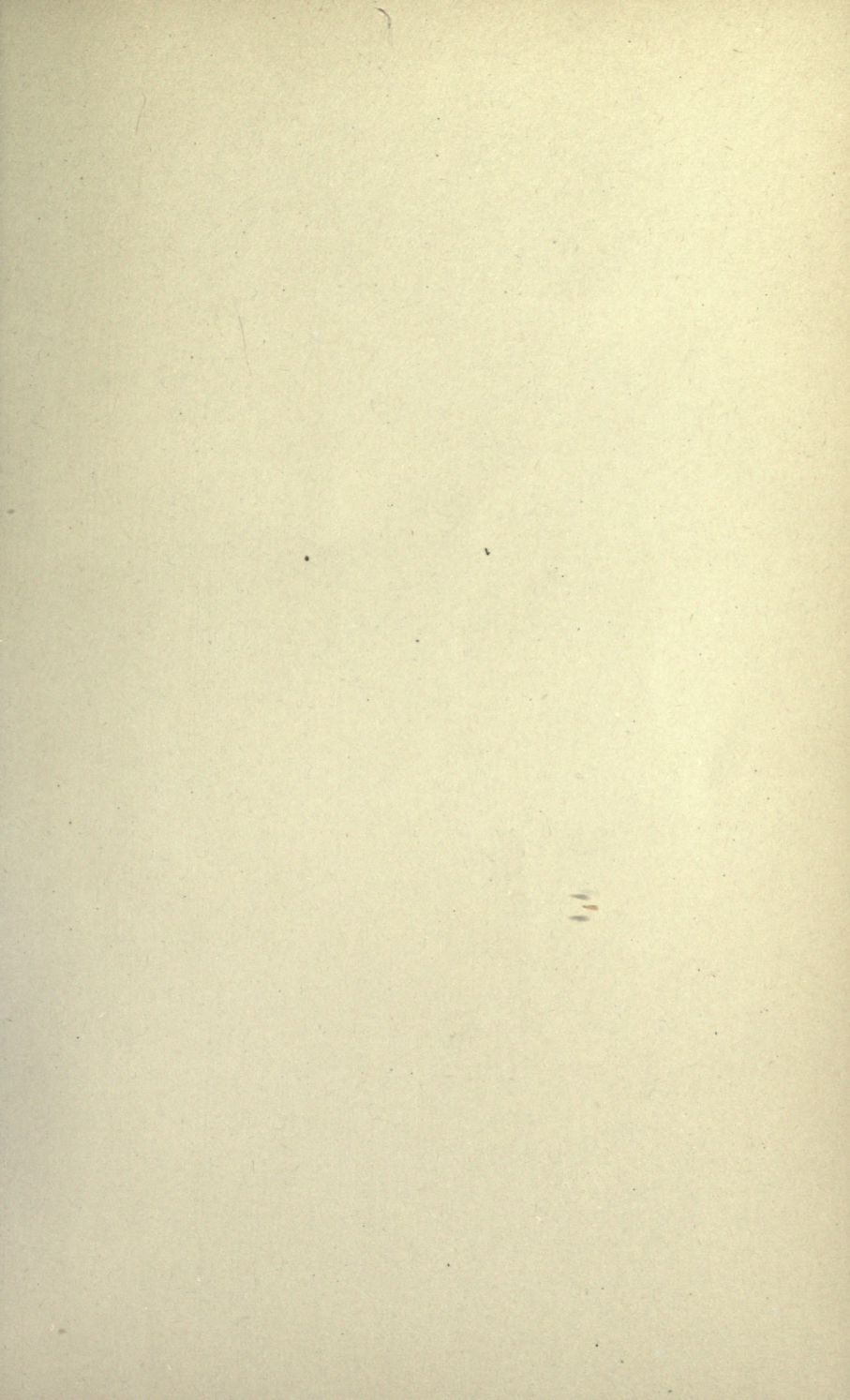




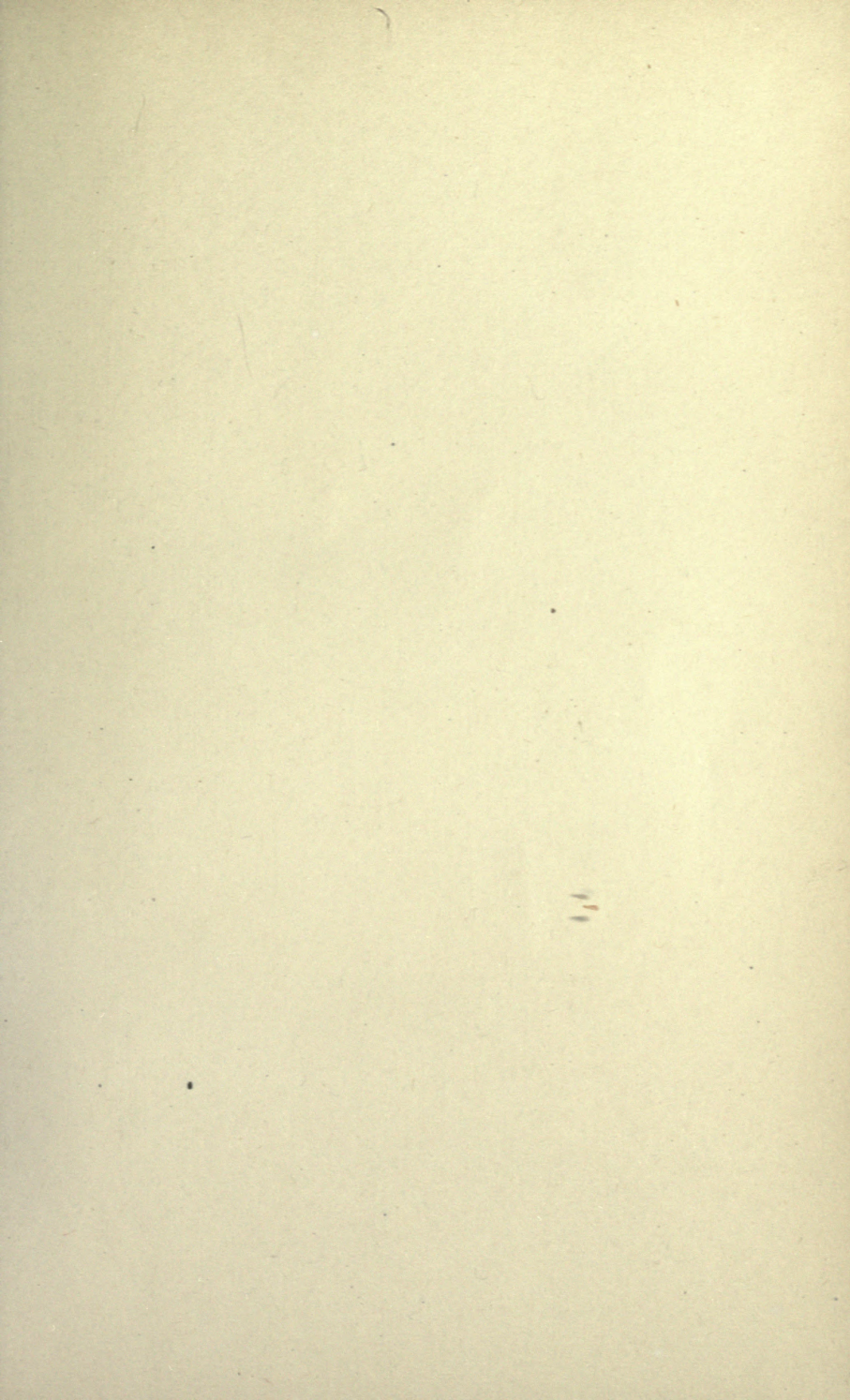




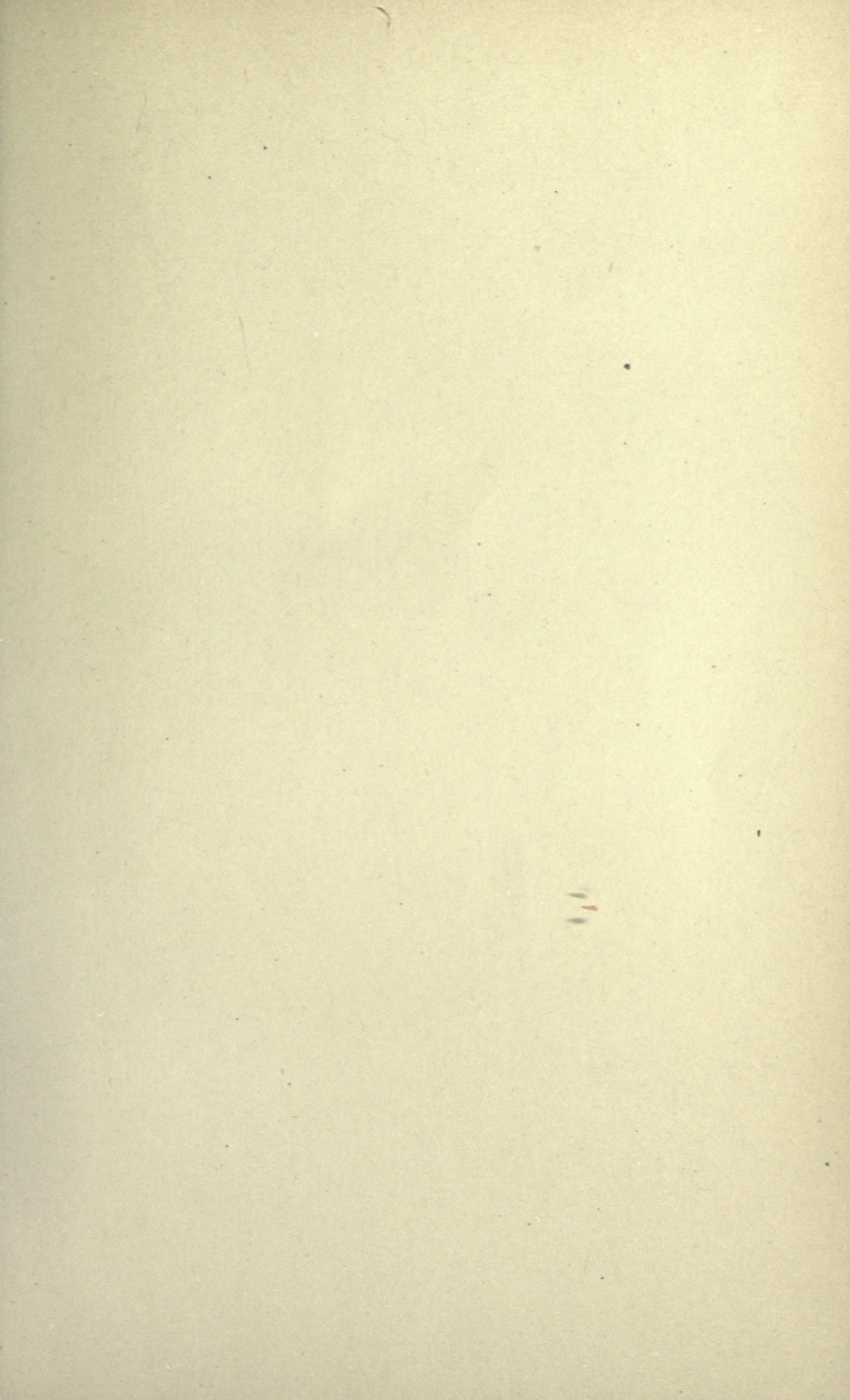




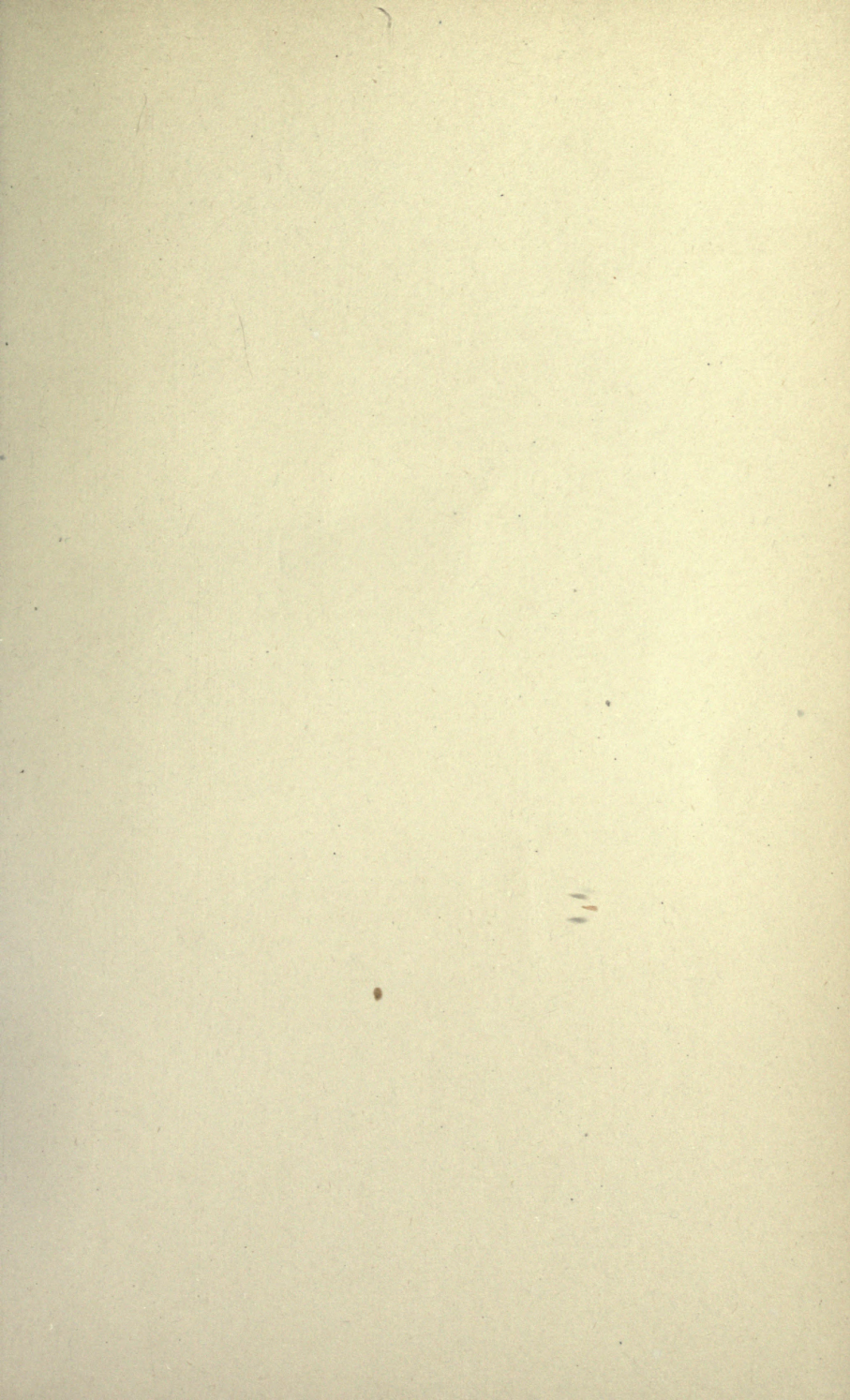




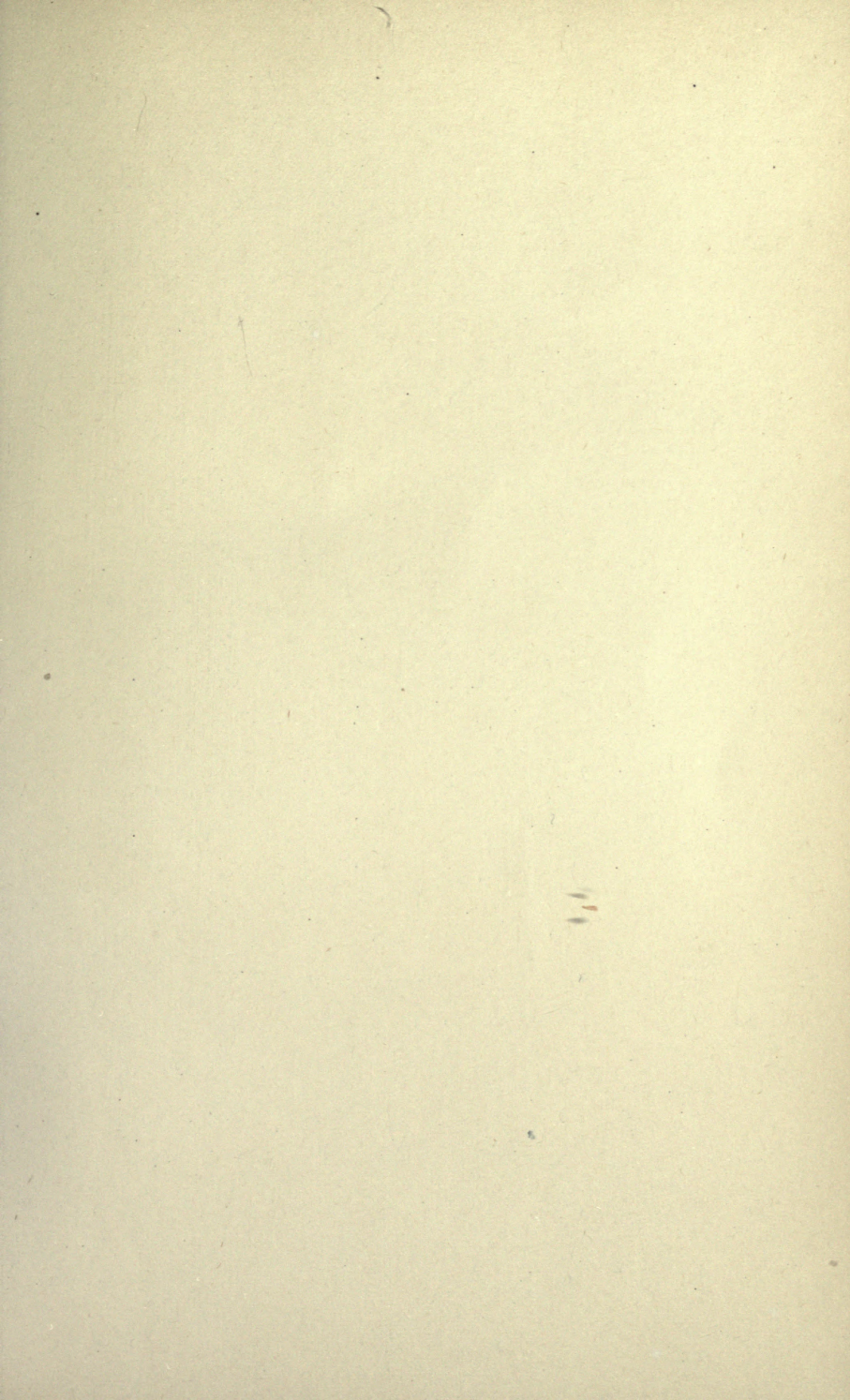




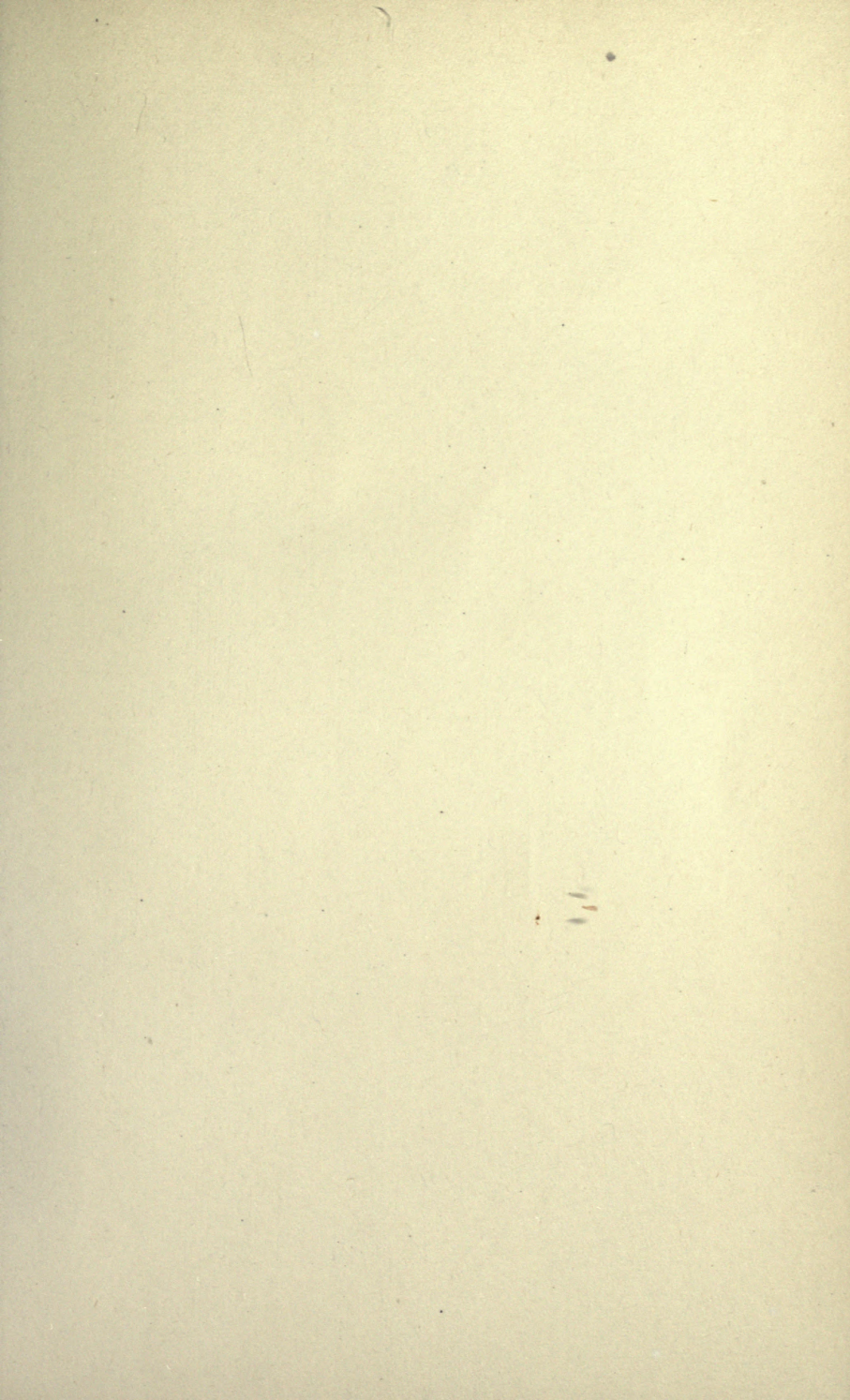








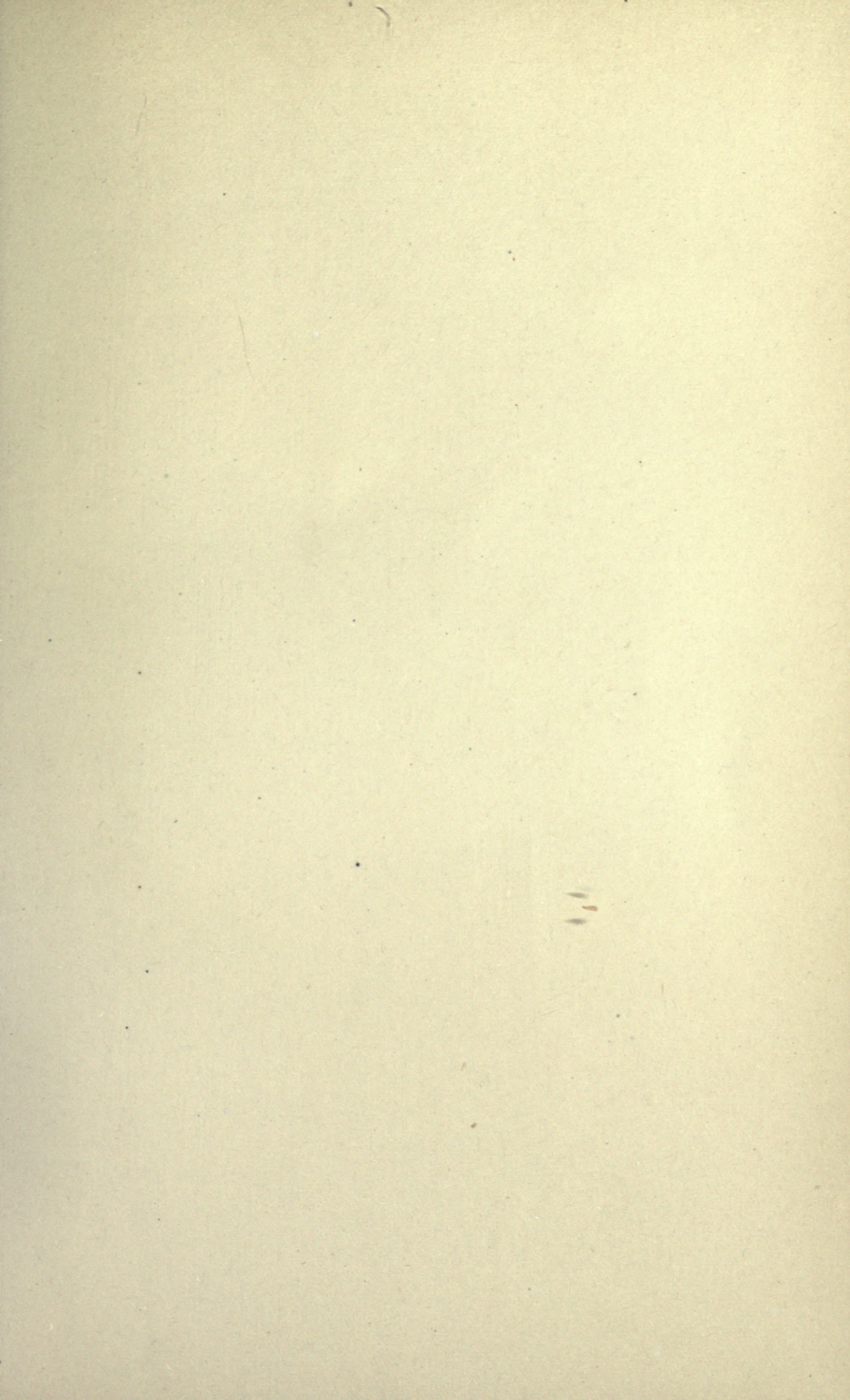




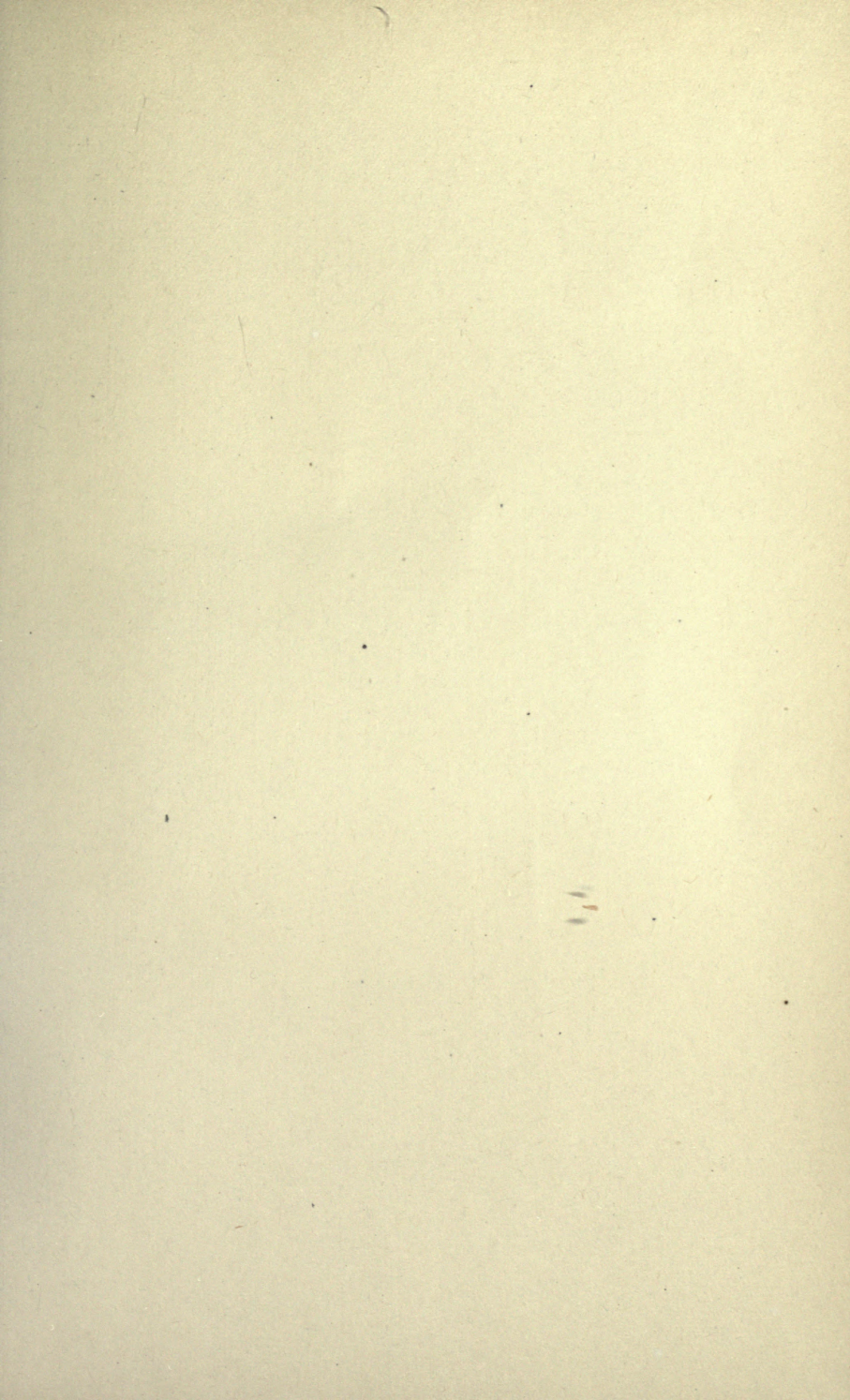




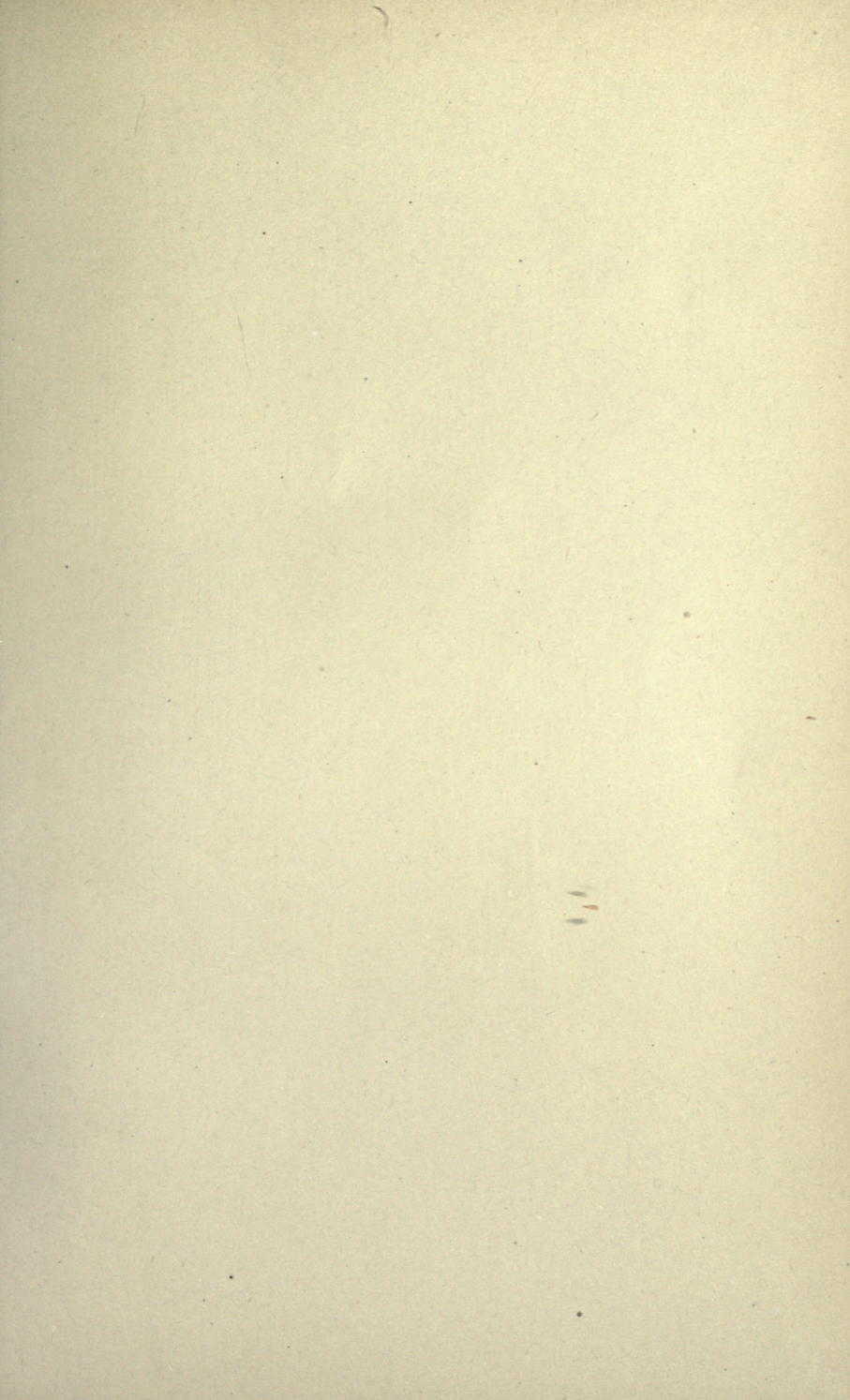




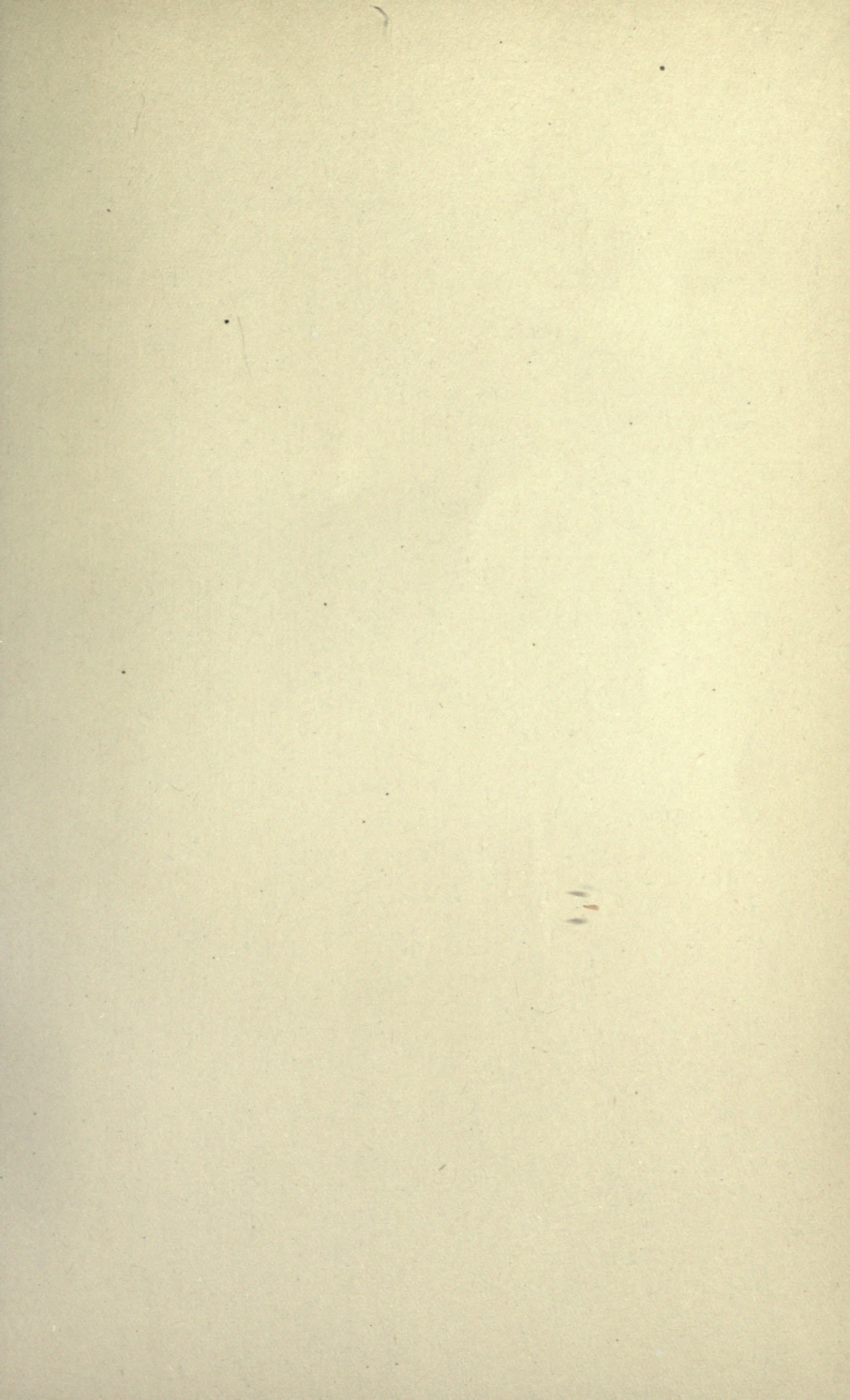




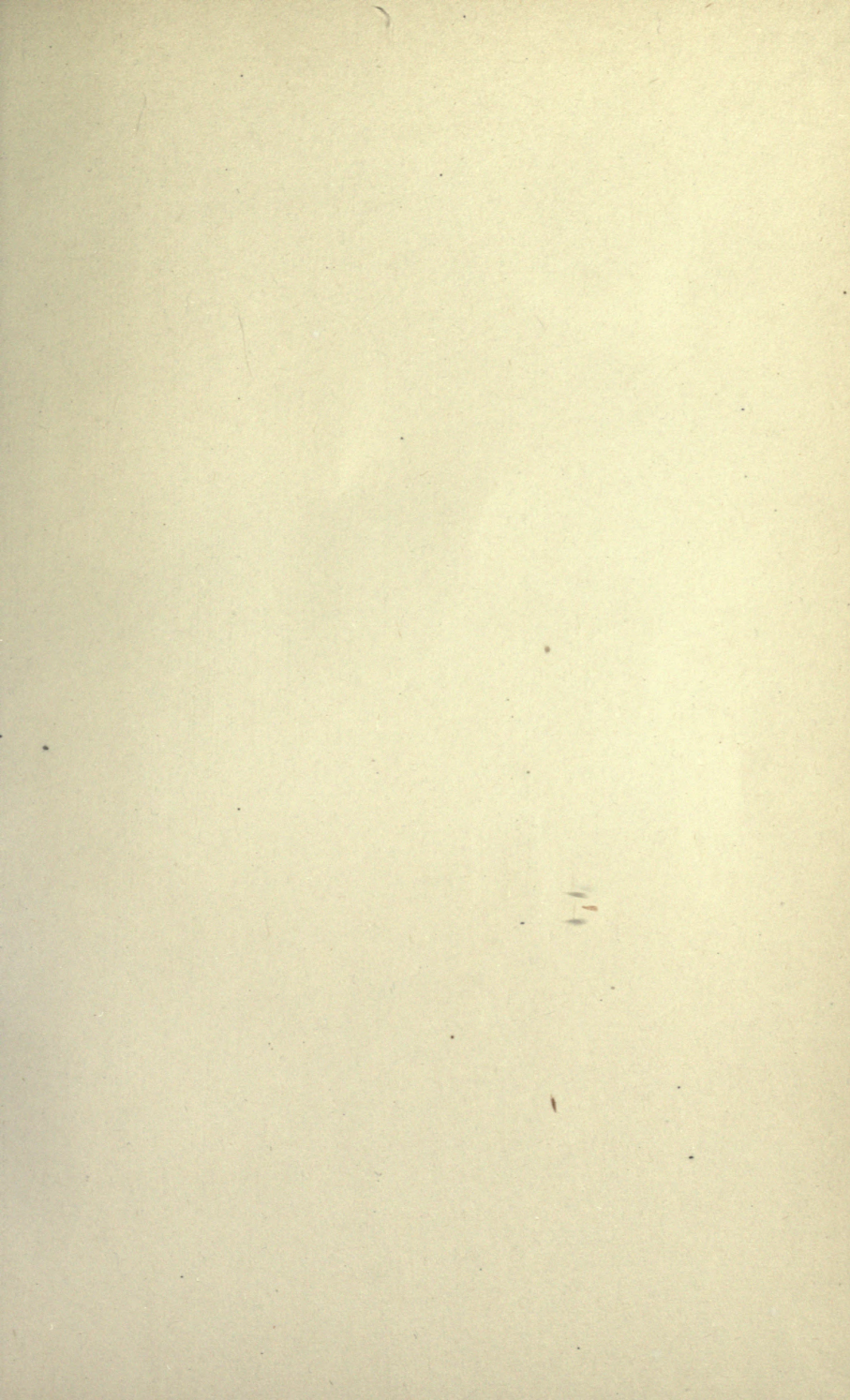




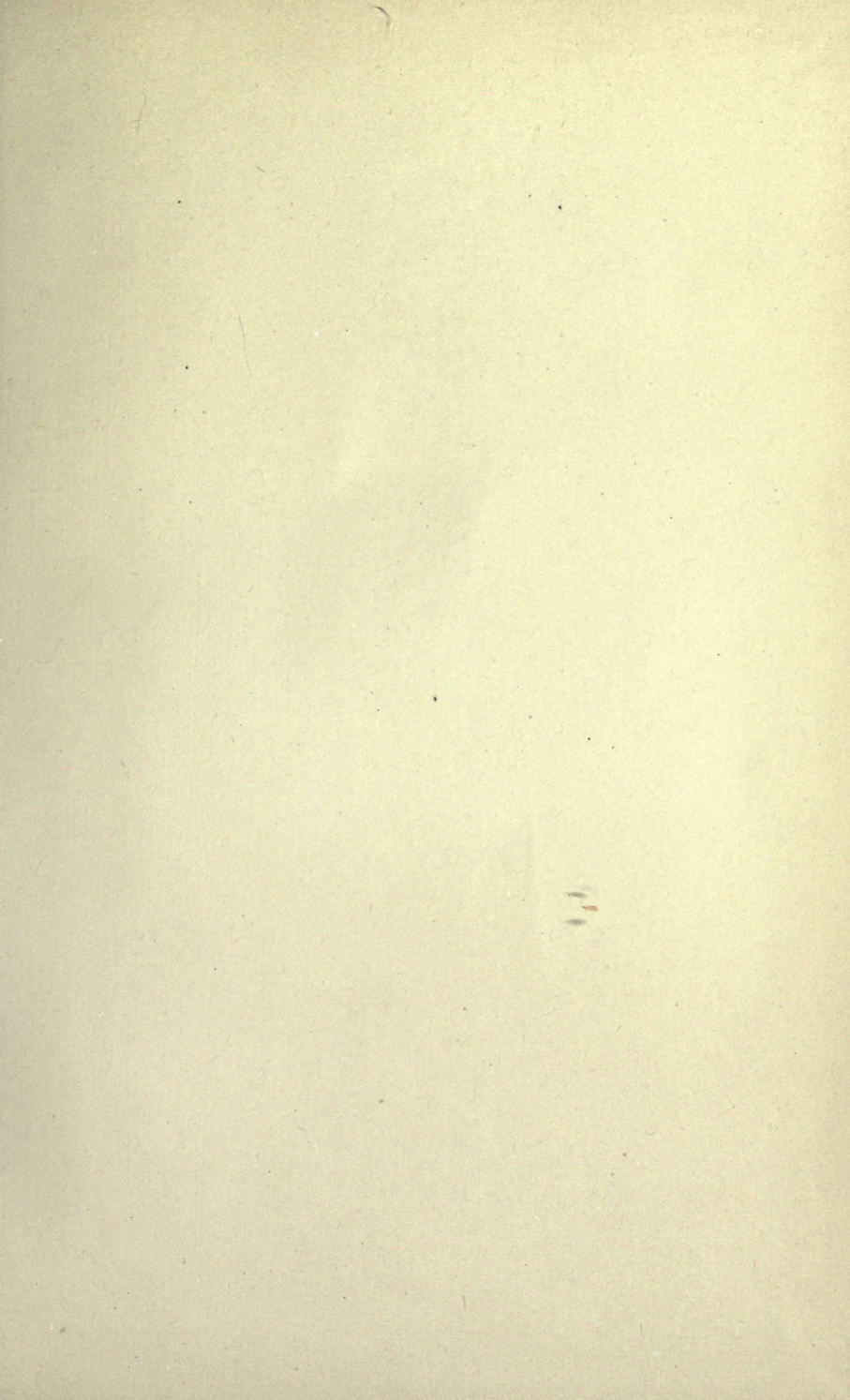




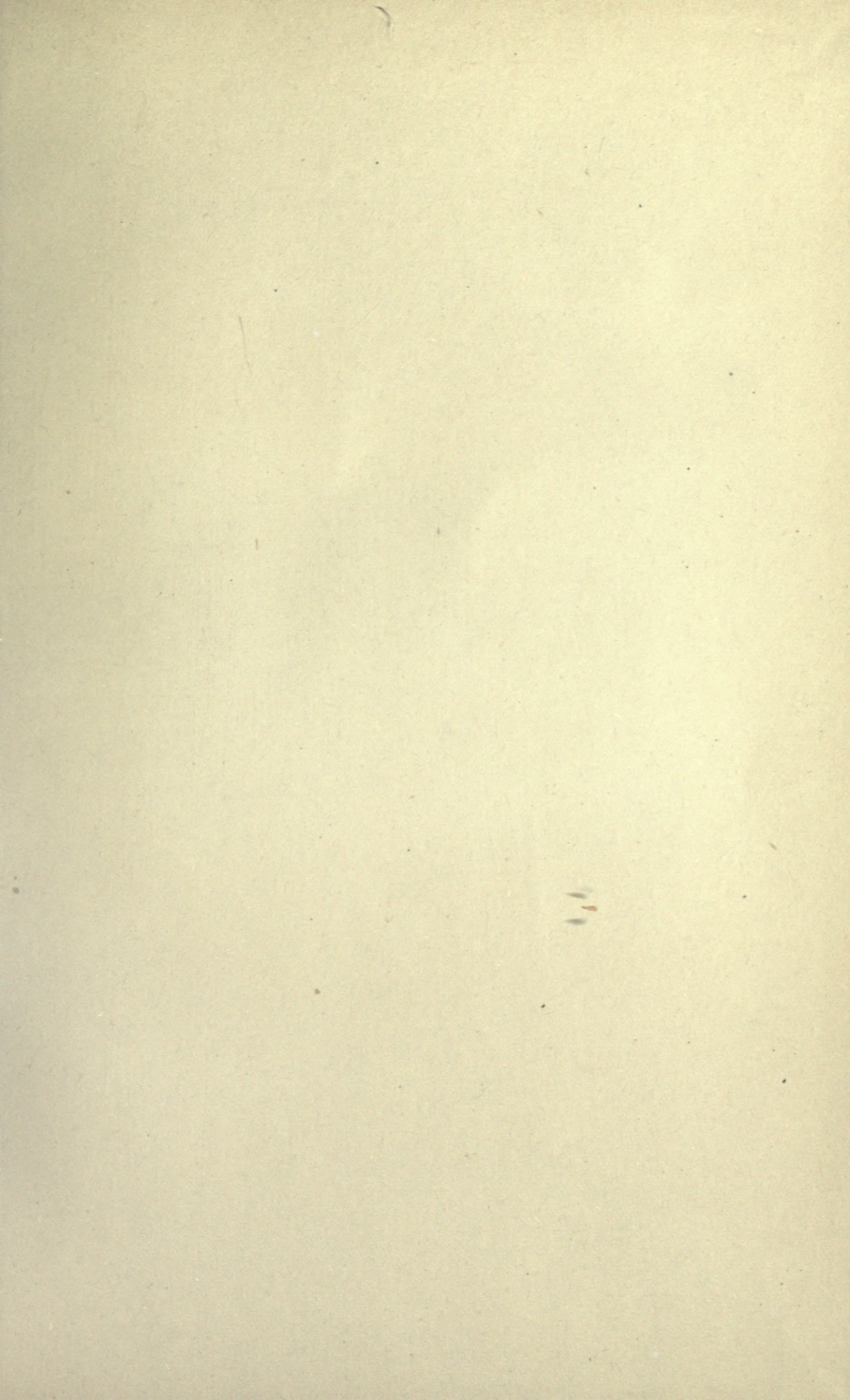




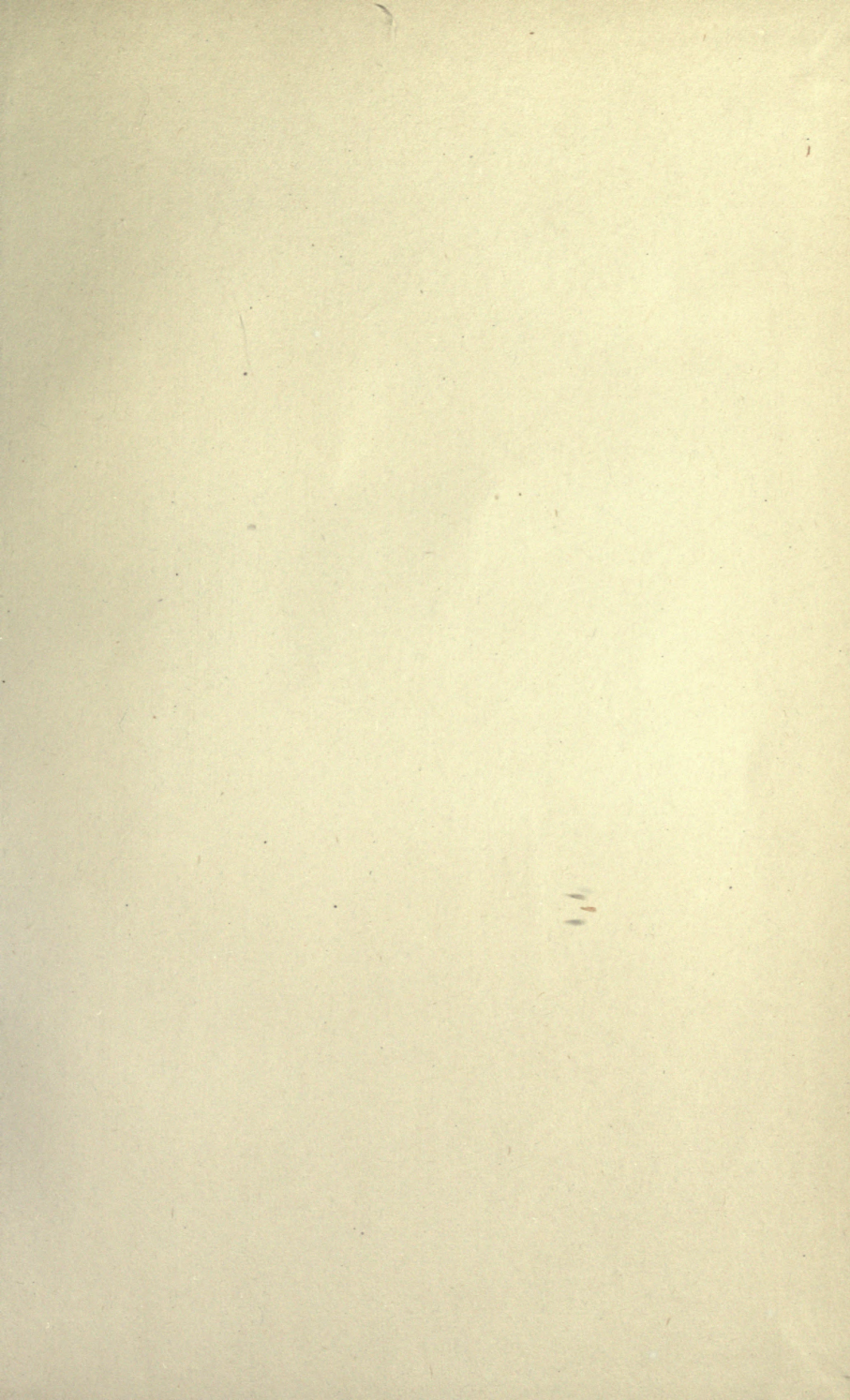




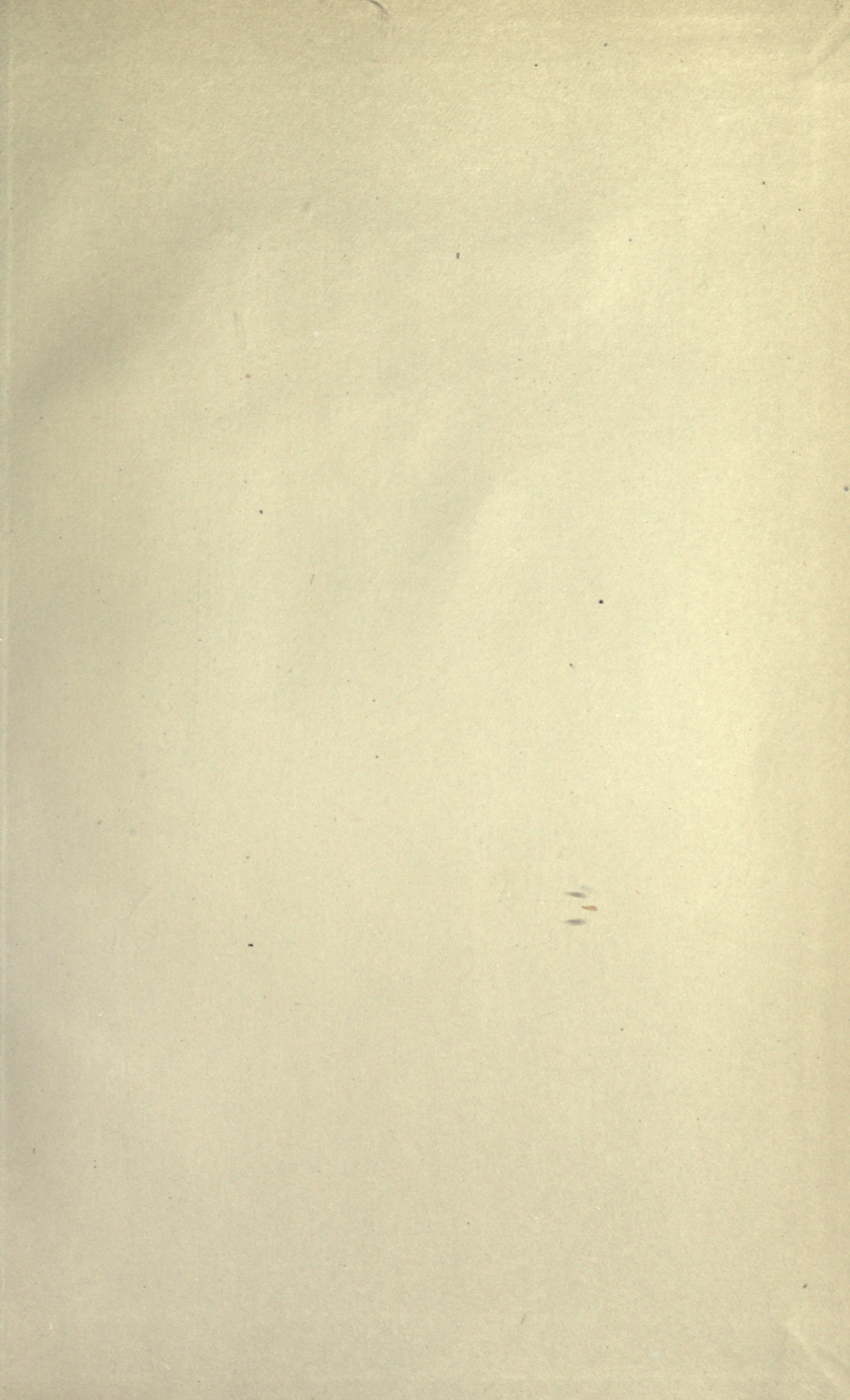












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